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F21 Fish and Game
1979 Instream flow
evaluation for
selected streams
in the upper
Missouri River

Instream
FLOW EVALUATION FOR SELECTED STREAMS
IN THE
UPPER MISSOURI RIVER BASIN

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TABLE OF CONTENTS

INTRODUCTION	1
DESCRIPTION.	2
METHODS.	5
RIVERS AND STREAMS	
Madison River	11
West Gallatin River	30
East Gallatin River	42
Gallatin River.	54
Beaverhead River.	58
Big Hole River.	72
Ruby River.	90
Red Rock River.	100
Jefferson River	105
Boulder River	115
Spring Creeks	
Ben Hart Creek	121
O'Dell Creek	124
Poindexter Slough.	127
Thompson Creek	130
Missouri River	
Headwaters to Canyon Ferry Reservoir	132
Sixteenmile Creek	138
Prickly Pear Creek.	151
Missouri River	
Holter Dam to the mouth of the Smith River.	157
Little Prickly Pear Creek	165
Big Spring Creek.	176
Belt Creek.	180
Smith River	187
Marias River.	194
Musselshell River	205
Redwater River.	222
Poplar River.	229
PRELIMINARY SUMMARY OF RESOURCE CONFLICTS AND CONCERNS	246
LITERATURE CITED	248



INTRODUCTION

The Missouri River Basin Commission (MRBC) is coordinating a Level B study of the upper Missouri River Basin. The purpose of the study is to generate a framework plan that can be used for the orderly development of the region's land and water resources.

A Level B study requires only "reconnaissance" level information, however, the information contained in this report is considerably more detailed and the instream flow recommendations are, in most cases, based on on-site field investigations. The upper Missouri River basin encompasses a range of aquatic ecosystems far too divergent and complex to be adequately addressed in a limited reconnaissance type effort. As a result, this study addresses specific instream flow requirements for selected streams in the drainage, utilizing long-term fish population data, physical stream channel measurements, predictive hydraulic programs and existing biological data wherever possible. Gaps in biological and stream flow data have been identified as well as existing resource conflicts. On streams where little biological or stream flow data currently exist, the instream flow recommendations may be subject to change as additional data become available.

An accurate assessment of instream flows is vital to any water planning or allocation study. The amount of water allocated to instream uses may have a significant effect on water availability for consumptive users. On the other hand, an improper allocation for instream purposes can cause significant degradation to the aquatic resources of the area as well as adversely affecting other instream concerns.

The amount of water determined necessary for instream purposes depends, to a large degree, on the level of maintenance sought or protection afforded to the aquatic resource. For example, it may take considerably more water to sustain fish populations at levels high enough to support a good sport fishery than merely to sustain the population at a very low or survival level, yet both flows may be defined as a type of "minimum" flow.

To better define the relationship between flow regimes, habitat conditions and fish populations, various levels of aquatic habitat potential are defined which range from base survival levels to optimum habitat conditions. Since the aquatic habitat of a river channel is directly related to the amount of water in that channel, a particular discharge regime becomes an integral part of a specific level of habitat potential. Flow regimes for instream consideration can be related to the following levels of aquatic habitat potential:

1. Optimum Level of Aquatic Habitat Potential - The discharge regime which allows for the maximum expression of the carrying capacity of aquatic populations consistent with the physical constraints of channel configuration, cover and general productivity of the drainage. In some cases, this would require a return to a pristine flow regime or one as it existed prior to significant water depletions. In others, this level of habitat maintenance would imply securing the present flow regime with little or no future depletions.

2. High Level of Aquatic Habitat Potential - That flow regime which will consistently produce abundant, healthy and thriving aquatic populations. In the case of game fish species, these flows would produce abundant game fish populations capable of sustaining a good to excellent sport fishery for the size of stream involved. For rare, threatened or endangered species, flows to accomplish the high level of aquatic habitat maintenance would: 1) provide for high population levels to ensure the continued existence of that species or, 2) provide for flow levels above that which would adversely affect the species.

3. Low Level of Aquatic Habitat Potential - Flows to accomplish the low level of aquatic habitat maintenance would provide for only a low population abundance of the species present. In the case of game fish species, a poor sport fishery could still be provided. For rare, threatened or endangered species, their populations would exist at low or marginal levels. In some cases, this flow level would not be sufficient to maintain certain species.

4. Critical Level of Aquatic Habitat Potential - A flow regime which would eliminate many of the aquatic species. Only the more adaptable and resistant species would survive at levels capable of recovering if more desirable flows were provided. Rare, threatened and endangered species would probably be eliminated. A sport fishery could not be provided with these flows.

Where sufficient data existed, flow regimes were identified which would maintain the high and low levels of aquatic habitat potential. Only in the case of the spring creeks were flows requested which would provide the optimum level of aquatic habitat potential.

DESCRIPTION

The Missouri River originates near Three Forks, Montana at the junction of the Madison, Gallatin and Jefferson rivers (Figure 1). In Montana, the spectrum of aquatic habitats ranges from the clear, cold headwater tributaries supporting nationally renowned wild trout fisheries to a large, warm water river where prehistoric species such as paddlefish and sturgeon mingle with channel catfish, walleye, sauger and burbot. Portions of the Missouri mainstem and selected tributaries have been classified as "Blue Ribbon" by the Montana Fish and Game Commission, an indication of the highest quality trout streams. In addition, a 149-mile reach of the mainstem between Fort Benton and the Fred Robinson Bridge has achieved the status of a Wild and Scenic River.

The Missouri River has played a pivotal role in Montana's history. Draining a major portion of the state, it initially provided a vital transportation artery for the westward migration of settlers and the eastward flow of the main frontier commodity - fur. Fur trappers and traders floated downstream from the headwater tributaries to rendezvous at Fort Benton with steamboats churning their way upstream from distant towns.

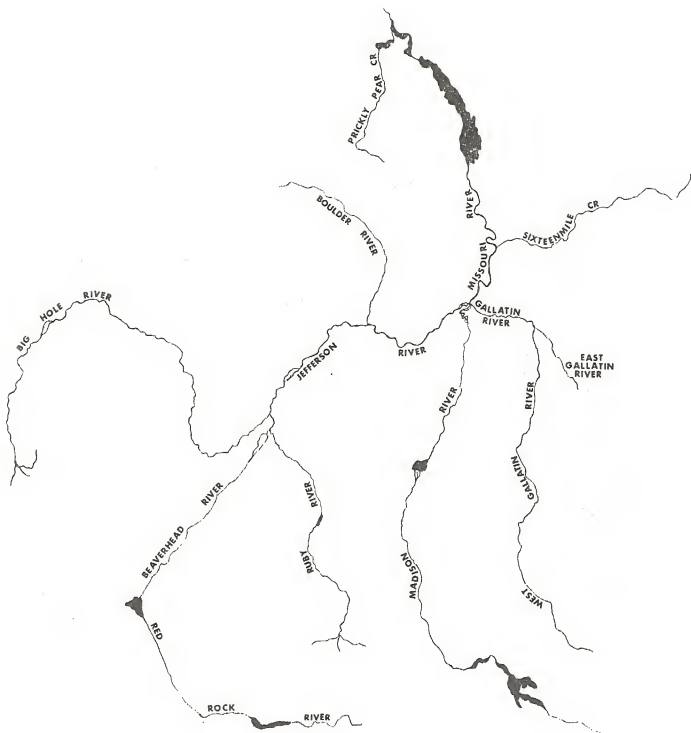


Figure 1. Map of the Missouri River and tributaries upstream of Hauser Dam.

As the land tamed and railroads pushed westward to assume the burden of transport, the upper Missouri began to lose much of its appeal as an avenue of commercial and passenger traffic. With the passage of time, the river began to assume a new importance. Settlements were established on its banks and agriculture developed in the valleys. Water was now needed by ranchers and farmers to grow crops and by municipalities for drinking and diluting urban wastes.

The basic character of the river also changed. Much of the free-flowing nature of the mainstem was lost through impoundments as several dams were constructed for flood control, power generation and irrigation. Native wildlife populations associated with the upper Missouri drainage also experienced change over time. Gone are the grizzly and bison from historic bottomland ranges. Elk, while thriving in mountain areas, have had their bottomland populations significantly reduced. Disruption of native sagebrush areas has adversely affected sage grouse populations while the introduced ring-necked pheasant and Hungarian partridge flourish with a modest degree of agricultural activity. The white-tailed deer, a species highly adapted to agricultural areas, has recently extended its range into many areas of the upper Missouri drainage.

The fish fauna has also changed considerably. The native cutthroat trout and arctic grayling which dominated much of the cold water habitat of the Missouri drainage have been replaced by rainbow, brown and brook trout, introduced to the drainage in the late 1800's and early 1900's. Of the native salmonids, only the mountain whitefish has prospered. Remnant populations of Missouri River cutthroat trout still occur in a few small tributaries and a dwindling arctic grayling population is found in the upper Big Hole River. This grayling population represents the only remaining major stream dwelling population in the contiguous United States south of Alaska.

The trout fishery of the many cold water impoundments of the Missouri drainage is primarily maintained by annual plants of juvenile hatchery rainbow trout. These impoundments also provide a sport fishery for other nonnative species such as brown trout, kokanee, yellow perch, walleye and the native burbot. In addition, undesirable nongame species such as carp, suckers and chubs proliferate.

Below Great Falls, the Missouri River and the mainstem impoundments revert entirely to a warm water environment supporting such native fish as sauger, shovelnose sturgeon, pallid sturgeon, channel catfish, paddlefish, burbot, and nonnatives such as walleye, yellow perch, carp and northern pike. This portion of the Missouri also provides a limited commercial fishery for goldeye, buffalo, carp, freshwater drum, and other nongame species.

In addition to providing a diverse and nationally renowned sport fishery the Missouri drainage provides other recreational opportunities. All forms of recreational boating from white water kayaking on the headwater tributaries to power boating on the mainstem below Fort Peck Reservoir are popular. The drainage

also supports diverse populations of huntable game species ranging from common game birds such as ring-necked pheasant, Hungarian partridge, and sharp-tailed grouse of the river bottomlands to big game trophies such as elk, mountain lion and big horn sheep of the adjacent mountainsides.

The high quality of water-based recreation in the basin is dependent on adequate stream flow. Consumptive uses are generally in conflict with instream purposes. In some areas, excessive consumptive use demands have severely depleted certain stream sections and adversely affected the recreational potential of those areas. The maintenance of the existing high quality recreation can only be assured by securing adequate amounts of water for instream purposes.

METHODS

The following methods were used to determine instream flow needs for different periods of the year.

HIGH FLOW PERIOD - Dominant Discharge/Channel Morphology Concept

Several major components of aquatic habitat in river systems are related to the physical features and form of the river channel itself. Over time, aquatic populations have adapted and thrived within the physical constraints of channel configuration and flow. Basic to the maintenance of the existing aquatic populations is the maintenance of the existing habitat that has historically sustained them.

It is generally accepted that the major force in the establishment and maintenance of a particular channel form in view of its bed and bank material is the annual flood characteristics of the river. It is the high spring flows that determine the shape of the channel rather than the average or low flows.

Most streams and rivers in the Missouri drainage in Montana which are not regulated are characterized by an annual spring high water period which normally occurs during May and June and result from snowmelt in the mountainous headwaters. Lowland prairie streams in the eastern part of the state, which lack mountain headwater areas, have a highwater period which occurs earlier and is the result of lowland snowmelt and runoff. Annual spring flow conditions on unregulated streams are heavily dependent upon snowpack and its rate of thawing. On regulated streams, the occurrence and magnitude of the high water period may vary depending upon reservoir operation and storage capacity.

The major functions of the high spring flows in the maintenance of channel form are bedload movement and sediment transport. It is the movement of the bed and bank material and subsequent deposition which forms the mid-channel bars and subsequently the islands. High flows are capable of covering already established bars with finer material which leads successively to vegetated islands. Increased discharge associated with spring runoff also results in a flushing action which removes deposited sediments and maintains suitable gravel conditions for aquatic insect production, fish spawning and incubation.

Reducing the high spring flows beyond the point where the major amount of bedload and sediment is transported would interrupt the ongoing channel processes and change the existing channel form and bottom substrates. A significantly altered channel configuration would affect both the abundance and species composition of the present aquatic populations by altering the existing habitat types.

Several workers (Leopold, Wolman and Miller 1964, U. S. Bureau of Reclamation 1973, and Emmett 1975) adhere to the concept that the form and configuration of river channels are shaped by and designed to accommodate a dominant discharge. The discharge which is most commonly referred to as a dominant discharge is the bankfull discharge (Leopold, Wolman and Miller 1974, Emmett 1975). Bankfull discharge is defined as that flow when water just begins to overflow onto the active floodplain.

Bankfull discharge tends to have a constant frequency of occurrence among rivers (Emmett 1975). The recurrence interval for bankfull discharge was determined by Emmett (1975) to be 1.5 years and is in close agreement with the frequency of bankfull discharge reported by other studies (Leopold, Wolman and Miller 1964, Emmett 1972).

The bankfull discharge for streams and rivers of the upper Missouri River drainage was estimated by using the $1\frac{1}{2}$ year frequency peak flow. The $1\frac{1}{2}$ year frequency peak flow was determined by interpolation between the 1.25 and 2 year frequency peak flows as supplied by USGS for the streams in question.

It is not presently known how long the bankfull flow must be maintained to accomplish the necessary channel formation processes. Until studies further clarify the necessary duration of the bankfull discharge, a duration period of 24 hours was chosen.

A gradual rising and receding of flows should be associated with the dominant discharge and the shape of the spring hydrograph should resemble that which occurs naturally. USGS flow records were used to determine the time when the high flow period and peak flow normally occurs on a given stream. The dominant discharge is requested for that period when it normally occurs. Flows are increased from a base flow level to the dominant discharge in 2-week intervals at the 70th percentile flow level, corresponding to the natural timing of the high flow period.

It is apparent that the high water period has a major function in maintaining existing aquatic habitat conditions. Since the wetted perimeter analyses is based on the existing channel configuration, the same flow regime for the high water period should be used for both the high and low level of aquatic habitat potential.

The high flow months are the least likely periods to be affected by water depletions since withdrawals make up a significantly smaller percentage of the flow during spring runoff than during the low flow months of late summer and winter. It is likely that the high flow months can withstand substantial withdrawals and not alter the basic functions of

channel maintenance. The major threat to channel maintenance functions during the high flow period are large water storage projects which have the capability of capturing a large portion of the high flows for later release. The loss of the dominant discharge flow through mainstem impoundment projects can result in a drastically altered channel form.

LOW FLOW PERIOD - Wetted Perimeter Method

The relationship between wetted perimeter and flow was used to derive instream flows for most stream reaches. Wetted perimeter is the distance along the bottom and sides of a channel in contact with water (Figure 2). As the flow in a cross-section of a stream channel decreases, the wetted perimeter also decreases, but the rate of loss of wetted perimeter is not constant over a given range of flows. An example of a relationship between wetted perimeter and flow in a channel cross-section is given in Figure 3. There are generally two points on the plot of wetted perimeter versus flow at which the rate of loss of wetted perimeter is significantly changed. In the example (Figure 3), these inflection points occur at approximate flows of 300 and 600 ft^3/s . Fish population and flow data collected by the Montana Department of Fish and Game indicate that the flows at which the two inflection points occur are valid estimates of the flows needed to maintain a low and high level of aquatic habitat potential. In the example (Figure 3), flows less than approximately 300 ft^3/s would provide a low level of aquatic habitat potential and flows greater than approximately 600 ft^3/s would provide a high level of aquatic habitat potential.

Most of the relationships between wetted perimeter and flow for the stream reaches were derived using the IFG4 hydraulic simulation computer program developed by the Cooperative Instream Flow Service Group of the Fish and Wildlife Service in conjunction with the Bureau of Reclamation (Bovee and Cochnauer 1977). Field survey data were collected for at least five cross-sections within a stream reach at two-three different flows. The IFG4 program used this data to predict the wetted perimeter for each cross-section at flows selected by the investigator. The computed wetted perimeters at each flow of interest for all cross-sections were averaged, giving the average wetted perimeter for the stream reach for each flow of interest. Instream flow recommendations were obtained from the plots of average wetted perimeter versus flow. The inflection points on these plots were visually determined.

Some of the relationships between wetted perimeter and flow were derived using the Water Surface Profile (WSP) computer program of the Bureau of Reclamation. A general description of the WSP program and a discussion of field data requirements are given by Spence (1975). Field data for the WSP program were collected for at least five cross-sections within a stream reach.

Long-term fish population and flow data were also used to derive instream flows for selected river reaches. The instream flows derived from this biological data are the basis of and verify the accuracy of the wetted perimeter method for deriving

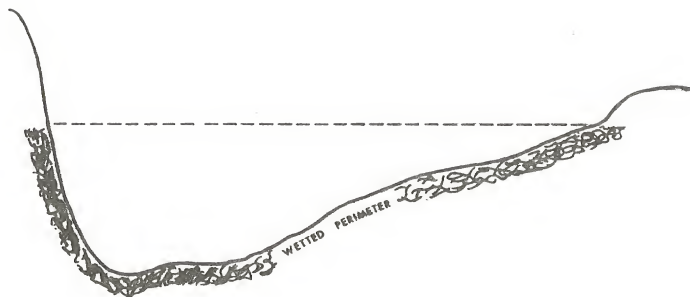


Figure 2. The wetted perimeter in a channel cross-section.

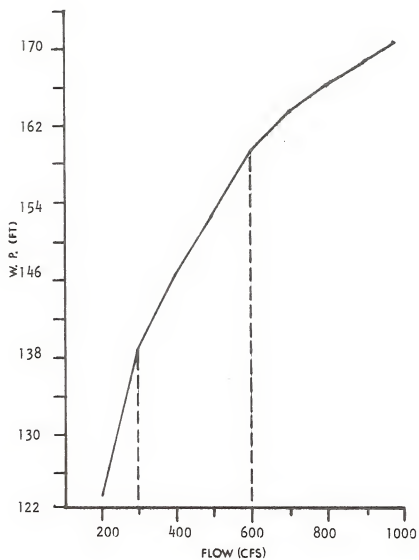


Figure 3. An example of a relationship between wetted perimeter and flow in a channel cross-section.

instream flows. A discussion of the fish population, flow and wetted perimeter data collected in each of the selected river reaches and a comparison of the instream flows derived from the two methods are included in later sections of this report (pages 16, 35, 37, 67 and 70).

The relationship between wetted perimeter and flow for a given stream is determined principally by the shape of the river channel. Since channel shape and form are primarily functions of the high water period, the same request for the high water period would be necessary for maintaining both the high and low level of aquatic habitat potential.

For streams where other data or methods were used to determine instream flows, additional information will be included in that section of the report dealing with the specific stream.

1. RIVER

Madison River

2. GENERAL DESCRIPTION

The Madison River originates in Yellowstone National Park at the junction of the Firehole and Gibbon rivers. It then flows in a northerly direction for approximately 140 miles to Three Forks, Montana where it joins the Jefferson and Gallatin rivers to form the Missouri River (Figure 4). There are two man made impoundments on the river - Hebgen Reservoir, located 1.5 miles downstream from the park boundary, and Ennis Reservoir, located 58 miles downstream from Hebgen Reservoir. From its source in the park, the Madison flows across a high conifer forested plateau (7,000 ft or higher in elevation) to Hebgen Reservoir. Upon leaving Hebgen Reservoir, the Madison flows about 1.5 miles through a narrow canyon to Quake Lake, a natural lake formed by an earth slide during a major earthquake on August 17, 1959. From Quake Lake the river enters the upper Madison River valley where it flows about 51 miles before entering Ennis Reservoir. After leaving Ennis Reservoir, the Madison enters a narrow gorge (Bear Trap Canyon) where it flows about 15 miles before entering the lower Madison River valley for the final 18 miles to its junction with the Jefferson and Gallatin rivers.

The Madison River drains approximately 2,500 square miles. About 70% of the drainage is covered with coniferous forests. The riparian zone of the wide, open upper and lower Madison River valleys is vegetated with willow, alder, cottonwood, and an occasional conifer. Vegetation in the riparian zone of the lower Madison valley is denser than that in the upper valley. Agricultural lands in the upper and lower valley are primarily used for cattle grazing and hay production. The subdivision of agricultural lands along the river in the upper valley is increasing.

There are about 102 tributaries to Montana's portion of the Madison River. Most are short, small and intermittent. About 16 tributaries provide a significant trout fishery and/or waterfowl habitat.

The Madison River is one of Montana's premier wild trout rivers. Due to its national reputation, heavy fishing pressure, good access, high scenic value and excellent wild trout populations,

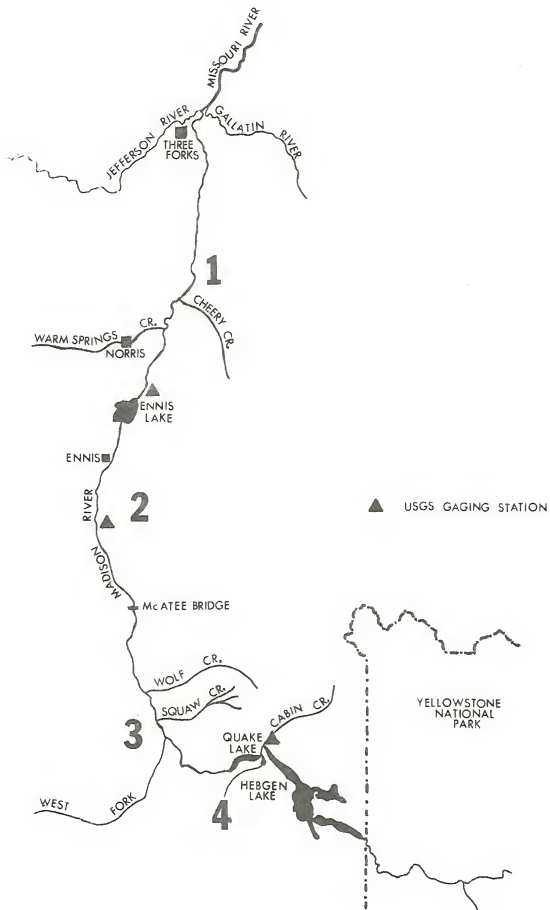


Figure 4. Map of the Madison River.

it has been classified as a "Blue Ribbon" trout stream. The 90 miles of river within Montana represent 22% of Montana's "Blue Ribbon" water.

Fishing pressure has increased more than fourfold since the early 1950's. For the 90 miles in Montana, angling pressure increased from 22,660 man days in 1952 (FWS 1952) to 38,000 in 1967 (Vincent 1969). From May 1975 to April 1976 fishing pressure was estimated at 97,570 man days. Nonresidents comprised 27% of the total pressure in 1952 and 61% in 1975-76. The river is presently managed as a wild trout fishery. The last stocking of hatchery trout occurred in 1973.

Float fishing and recreational floating are popular on the Madison River. Boat pressure is high when compared to other rivers within the state. Between May 20 and September 15, 1976, an average of 19 boats per day were counted on a section of the river in the upper valley. Maximum use was 50 boats per day (Vincent 1978).

Flows in the Madison River are regulated by two man made reservoirs. Hebgen Reservoir, built in 1915 by the Montana Power Company, stores water for downstream electric power generation. Water storage usually occurs during the snow runoff period of mid-May through early July. Stored water is released to downstream reservoirs during the fall (October-December). Fall releases usually range from 1,500 to 2,200 cfs at Hebgen Dam. Ennis Reservoir, built in 1908 by the Montana Power Company, has a rather stable water level with little storage capacity of its own. Its primary function is to create a head for the electric power generating facility immediately below Ennis Dam. Outflows from Ennis Reservoir are mainly regulated by Hebgen Reservoir.

Long-term flow records are available for three USGS gaging sites on the Madison River below Hebgen Dam. The mean flow for a 39-year period of record at the gage below Ennis Dam (near McAllister) was 1,762 cfs. Flows ranged from 210 to 9,550 cfs. The mean flow for a 13-year period of record at the gage upstream of Ennis (near Cameron) was 1,432 cfs. Flows ranged from 275 to 8,830 cfs. The mean flow for a 67-year period of record at the gage below Hebgen Dam (near Grayling) was 999 cfs. Flows ranged from 5 to 10,200 cfs. The river exhibits a larger base flow in proportion to its annual runoff than most rivers in Montana.

A 1969 state Law (Section 89-801, R.C.M. 1947) authorized the Montana Department of Fish and Game to appropriate water for instream uses on 12 rivers in the state. On the Madison River between the mouth and Ennis Dam, the department appropriated 1,200 cfs from January 1 to May 30 and 1,500 cfs from June 1 to December 31. Between Ennis Reservoir and the mouth of the West Fork, the department appropriated 900 cfs from January 1 to May 30 and 1,400 cfs from June 1 to December 31. Between the mouth of the West Fork and Hebgen Dam, 500 cfs were appropriated from January 1 to December 31.

Water chemistry of the Madison River has been described by Fraley (1978), Matney and Garvin (1978) and Wright and Mills (1968). In general, the water quality is good. The water is moderately hard, the pH ranges from 8.3-8.5, dissolved oxygen averages 10 mg/l, mean ammonia and nitrite levels are less than 0.009 mg/l, and nitrate averages 0.014 mg/l. Major contributors of sediment to the river are Cabin Creek, Beaver Creek, the Quake Lake slide area, and the West Fork of the Madison River.

3. REACH #1

From the mouth of the Madison River to Ennis Dam - 33 miles.
(T2N, R2E, Sec. 20 to T4S, R1E, Sec. 20)

Description

The upper 15 miles of reach #1 lie within the narrow Bear Trap canyon. The river is characterized by turbulent riffle-run areas interspersed with pools and large boulders. Gradient averages 21 ft per mile. Approximately 9 miles of the canyon are within the Bear Trap Primitive Area. Near the mouth of Cherry Creek, the river enters the lower Madison valley. The river channel becomes braided forming many islands and side channels. The immediate floodplain is vegetated with willow, alder and numerous cottonwoods. Gradient averages 16 ft per mile.

Considerable recreational floating occurs in reach #1. Rafting tubing, canoeing and float fishing are popular with recreationists.

Fishery

Brown trout, rainbow trout, mountain whitefish and an occasional grayling, brook trout and cutthroat trout comprise the sport fishery in reach #1. Brown and rainbow trout as large as 4 to 5 pounds are caught, but few exceed 2 pounds. In September 1977 the estimated number of 2 year and older (about 10 inches and larger) brown and rainbow trout in a study section within reach #1 was 665 and 531, respectively, per mile of river (Vincent 1978).

A 1975-76 estimate of angling pressure for reach #1 was 23,104 man days per year (MDFG 1976). Nonresidents comprised 20% of the pressure.

Waterfowl

Waterfowl use the river extensively during spring and fall migrations. Canada geese are common nesters on the islands in the lower valley. Other nesting waterfowl include common merganser, mallard, and blue-winged teal. Goldeneyes and mergansers commonly winter on the river. The hunting of ducks and geese is popular during the waterfowl season.

Wildlife

Big game animals found in the immediate vicinity of the river in the Bear Trap Canyon are mountain goat, black bear, mule deer and bighorn sheep. Mule deer and white-tailed deer are commonly found along the river in the lower Madison valley. Upland game birds include blue grouse, ruffed grouse, Hungarian partridge, sharp-tailed grouse, and an occasional ring-necked pheasant. Bald eagles and ospreys are commonly observed along the river. Golden eagles nest in the Bear Trap Canyon. Prairie falcons nest along the cliffs bordering the river in the lower Madison valley.

Environmental Concerns

Three major environmental problems exist or have existed within reach #1. They are periodic low flows during late winter to early spring, high summer (July - August) water temperatures due to the solar heating of Ennis Reservoir, and the absence of high water flows capable of flushing bottom sediments.

Prior to 1968, the Montana Power Company began storing water in Hebgen Reservoir in late February to early March before the spring runoff. This resulted in extremely low flows during late winter and early spring. These flow reductions severely reduced populations of trout. This problem was alleviated in 1968 when Montana Power agreed to start storing water when runoff begins in late April to early May. Trout populations increased following the flow increases provided by this change in policy.

A current problem is the warming of the Madison River below Ennis Reservoir (reach #1). Due to its wide, shallow configuration, the reservoir acts as a "heat trap" (Heaton 1961 and Vincent 1977). Between 1972 and 1977, the mean July-August water temperature below the reservoir was 66.6 F versus 59.8 F for the river above the reservoir. Minimum summer water temperatures below the reservoir are about 7 F higher than those above the reservoir. A maximum temperature of 82 F was recorded below the reservoir versus 72 F above the reservoir. The high summer water temperatures in reach #1 are affecting trout growth. Summer weight increases of 4 year old brown trout, rainbow trout and mountain whitefish in reach #1 are only 64, 66 and 53%, respectively, of those above the reservoir (Vincent 1978).

There is concern that the high flow releases from Hebgen Reservoir are incapable of adequately flushing the annual accumulation of bottom sediments in reach #1. High flow releases from Hebgen Reservoir are kept comparatively low in order to protect the Quake Lake outlet. The flows needed to transport the finer sediments should be defined.

Method Used For Flow Recommendations

Biological and flow data were used to identify the flows providing the low and high levels of aquatic habitat potential. In addition, the wetted perimeter method was used. Five cross-sections, located about 10 miles below Ennis Dam, were surveyed. The relationship between wetted perimeter and flow for the five cross-sections was generated using the IFG4 computer program.

Instream flows for the high water period (May 16 - July 15) are based on the dominant discharge/channel morphology concept (see page 5) and obtained from data supplied by the USGS (1975 and 1978). The 1½-year frequency peak flow was used to approximate the bankfull flow.

Flow Recommendations

Prior to 1968, the Montana Power Company began storing water in Hebgen Reservoir in late February to early March before the spring runoff. This resulted in extremely low flows in the Madison River during late winter and early spring. In 1968, Montana Power agreed to start storing water when runoff begins in late April to early May. This change resulted in higher flows in the Madison River from February to May.

Numbers of adult trout (age II and older) were estimated in a 4-mile section of reach #1 in spring 1967, prior to the flow changes, and in the spring of 1968, 1969, 1970 and 1971 after flows were increased (Table). The distribution of the average daily flows for the approximate 12-month period preceding each estimate shows the magnitude of the flow increases occurring after 1968 (Table). The number of trout dramatically increased following these flow increases. The highest estimate of trout numbers (12,248 per 4 miles in spring 1970) followed the 12-month period containing the highest flows. Between spring 1969 and spring 1970, 97.2% of the average daily flows exceeded 1,400 cfs and none were less than 1,240 cfs. The lowest estimate (6,779 per 4 miles in spring 1967) followed the 12-month period containing the lowest flows. Between spring 1966 and spring 1967, 18.1% of the average daily flows were less than 1,100 cfs versus 0-2.9% for the other years. This data suggest that flows greater than approximately 1,400 cfs would provide an aquatic habitat capable of supporting the highest numbers of adult trout while flows less than approximately 1,100 cfs cause severe reductions in numbers of adult trout.

The relationship between wetted perimeter and flow for a composite of five cross-sections in reach #1 is shown in Figure . The two inflection points occur at approximate flows of 900 and 1,350 cfs and correspond to the low and high levels of aquatic habitat potential, respectively (see page 7). The instream flows derived from the wetted perimeter method are very similar to those derived from the biological data.

The bankfull flow for reach #1 of the Madison River, estimated at 4,130 cfs, should be established for 24 hours during

Table 1. Distribution of the average daily flows during the approximate 12-month period preceeding the trout population estimates in a 4 mile section of reach #1 of the Madison River in Spring, 1967 through Spring, 1971.

AVERAGE DAILY FLOWS (ft ³ /s)														Est. Number Age II & Older Trout/4 miles
600 699	700 799	800 899	900 999	1000 1099	1100 1199	1200 1299	1300 1399	1400 1499	1500 1599	1600 1699	1700 1799	≥ 1800		
1966-67	1	16	10	8	36	37	37	63	42	26	17	9	90	6,779
1967-68	0	0	0	3	3	6	7	17	27	23	26	28	182	9,816
1968-69	0	0	0	2	9	10	19	18	26	55	37	31	171	9,625
1969-70	0	0	0	0	0	0	1	9	29	39	50	23	208	12,240
1970-71	0	0	0	1	2	6	8	16	15	92	13	15	192	11,613

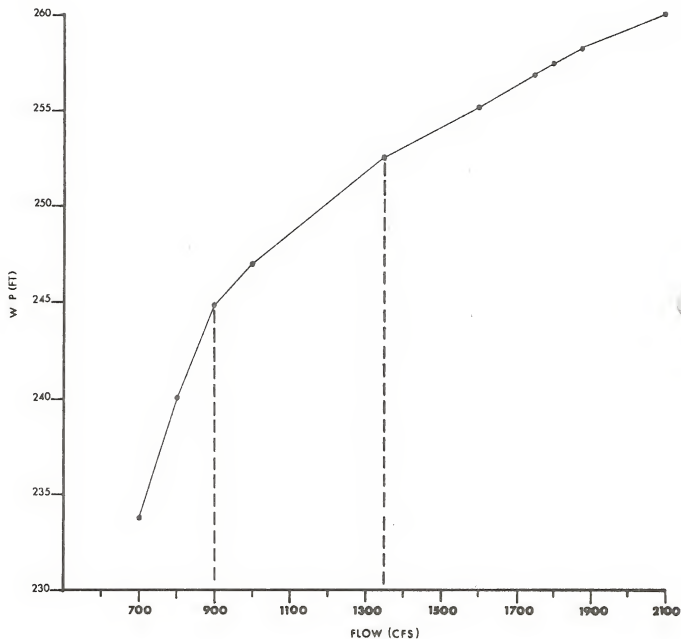


Figure 5. The relationship between wetted perimeter and flow for a composite of 5 cross-sections in reach #1 (from the mouth to Ennis Dam) of the Madison River.

June 1 - 15. For the remainder of the high water period (May 16 - July 15), the 70% exceedance flows are recommended (see page 5). The bankfull and 70% exceedance flows were computed from data collected at the USGS gage below Ennis Dam (near McAllister). Since the high water flows at this gage are regulated by Hebgen and Ennis Dams, the flow recommendations during the high water period may not be high enough to adequately flush the bottom sediments. Additional information is needed to better define these flows.

The instream flows that will maintain a low and high level of aquatic habitat potential are identified in Table 2. The instream flows recommended for reach #1 correspond to the high level of aquatic habitat potential and amount to 1.07 MAF per year. During most months, mean monthly flows exceed the recommended flows (Table 2). The recommended flows for January, February, and March are about equal to the mean monthly flows.

4. REACH #2

From Ennis Reservoir to McAtee Bridge - 24 miles.
(T6S, RLW, Sec. 4 to T8S, RLW, Sec. 36)

Description

Reach #2 lies within the upper Madison River valley. The upper 14 miles of river are wide (200-300 ft) and shallow. Much of the river is less than 3 ft in depth. The river consists primarily of riffle-run areas interspersed with large boulders. Few pools are found. The banks are primarily vegetated with willow and alder with an occasional cottonwood.

In the lower 10 miles, the river channel braids forming many islands and side channels. This section also consists primarily of riffle-run areas. Few pools are found. Much of the river is 2 - 5 ft in depth, with a maximum depth of about 6 ft. Bank vegetation is denser than that along the upper 14 miles. Cottonwoods are also more abundant.

The gradient in reach #2 averages about 17 ft per mile. The streambed consists primarily of boulder, cobble, and gravel. In 1972-77, summer water temperatures (July-August) averaged 59.8 F, considered ideal for optimum trout growth.

Fishery

Brown trout, rainbow trout, mountain whitefish and an occasional grayling, cutthroat trout, and brook trout comprise the sport fishery in reach #2. Brown trout, the dominant trout species, occasionally reach weights of 5 to 7 pounds. Brown trout in the 1.5 to 2 pound class are common. In September 1977, the estimated number of 2 year and older (about 10 inches and larger) brown and rainbow trout in a study section within reach #2 was 900 and 100, respectively, per mile (Vincent 1978).

Table 2 . Instream flows representing low and high levels of aquatic habitat potential compared to mean monthly flows for reach #1 of the Madison River.

Time Period	Flow					
	Low 1/		High 2/		Mean	
	CFS	AF	CFS	AF	CFS	AF
January	1,100	67,636	1,400	86,083	1,398	85,960
February	1,100	63,273	1,400	80,529	1,390	79,954
March	1,100	67,636	1,400	86,083	1,415	87,005
April	1,100	65,455	1,400	83,306	1,557	92,648
May 1-15	1,100	32,727	1,400	41,653		
May 16-31	1,514	48,048	1,514	48,048 3/	1,866	114,736
June 1-15	2,135	67,478 3/	2,135	67,478 3/		
June 16-30	2,007	59,712	2,007	59,712	2,952	175,656
July 1-15	1,623	48,288	1,623	48,288		
July 16-31	1,100	34,909	1,400	44,430	1,853	113,936
August	1,100	67,636	1,400	86,083	1,576	96,904
September	1,100	65,455	1,400	83,306	1,649	98,122
October	1,100	67,636	1,400	86,083	1,987	122,176
November	1,100	65,455	1,400	83,306	1,969	117,164
December	1,100	67,636	1,400	86,083	1,535	94,383
Total		888,980		1,070,471		1,278,644

1/ Low level of aquatic habitat potential.

2/ High level of aquatic habitat potential.

3/ Includes a flow of 4,130 cfs for 24 hours.

The annual stocking of catchable, hatchery rainbow trout in reach #1 was shown to suppress populations of wild rainbow trout and brown trout (Vincent 1973). During years when stocking occurred, populations of wild rainbow trout and older brown trout were about 15 and 50%, respectively, of those after 1973, when stocking was stopped. As a result of these findings, the stocking of hatchery trout was drastically curtailed on all rivers capable of maintaining wild trout populations.

A 1975-76 estimate of angling pressure for the Madison River between Quake Lake and Ennis Reservoir was 953 man days per mile (MDFG 1976). Nonresidents comprised 69% of the pressure.

Waterfowl

Waterfowl use the river extensively during spring and fall migrations. Of the various waterfowl nesting along the river, the Canada goose is the most important. The heaviest nesting concentration on the river occurs in reach #2 between Ennis Reservoir and the town of Ennis.

Wildlife

Big game animals using the floodplain area are elk, moose, mule deer, and white-tailed deer. Upland game birds include ruffed grouse, Hungarian partridge and an occasional ring-necked pheasant. The greater sandhill crane is a common nester along this reach. Bald eagles and ospreys are commonly observed along the river.

Environmental Concerns

In the past, severe flow reductions due to the water storage policy at Hebgen Reservoir occurred in the Madison River during the months of February through April (see Environmental Concerns for reach #1). This problem was alleviated in 1968.

Flow fluctuations during the goose nesting season can adversely affect gosling survival. Presently, the Montana Power Company is cooperating with the Montana Department of Fish and Game to minimize these fluctuations.

Interest has been expressed for a canal to service additional irrigators on the east bench of the upper Madison valley. Additional consumptive uses during the lower flow periods would conflict with the recreational potential of the Madison River.

Method Used For Flow Recommendations

Biological and flow data were used to identify the flow providing the low and high levels of aquatic habitat potential. The data needed to derive flow recommendations for the high water period (May 16 - July 15) are presently unavailable. This data will be available when flow records for the USGS gage near Cameron are summarized. Future flow requests during this period will be based on the dominant discharge/channel morphology concept (see page 5).

Flow Recommendations

Numbers of brown trout, the dominant trout species, and rainbow trout were estimated in a 5 mile section of reach #2 in fall 1967 through fall 1978. The estimates of juvenile (age I) brown trout reflect the flow patterns during this period. Numbers of wild rainbow trout and adult (age II and older) brown trout during portions of 1967-1978 were affected by the stocking of catchable, hatchery rainbow trout and intense fishing pressure. Population fluctuations could not be directly correlated to flow changes.

The approximate distribution of the average daily flows during the 12-month period preceding each estimate of the number of age I brown trout is given in Table 3. The lowest estimate (1,643 per 5 miles in September 1967) followed the lowest flows. Between October 1966 and September 1967, approximately 16.7% of the average daily flows were less than 650 cfs versus 0-1.5% for the other years. The highest estimate (7,876 per 5 miles in September 1976) followed the highest flows. Between October 1975 and September 1976, approximately 95.1% of the average daily flows exceeded 1,150 cfs and none were less than approximately 1,088 cfs. The data indicate that flows greater than approximately 1,150 cfs would provide an aquatic habitat capable of supporting the highest numbers of juvenile brown trout while flows less than approximately 650 cfs severely reduce the number of juvenile brown trout.

The flow that would maintain the highest population of adult trout in reach #2 could not be determined from the biological data. A study on the Beaverhead River, Montana showed that older trout required higher instream flows than did younger trout. Using the wetted perimeter method, the flow maintaining a high level of aquatic habitat potential in the Madison River in reach #3, upstream of reach #2, was determined to be 1,300 cfs. Based on these considerations, a flow of 1,300 is judged to maintain the high level of aquatic habitat in reach #2 as well.

The bankfull flow for reach #2, presently undetermined, should be established for 24 hours during June. During the remainder of the high water period (May 16 - July 15), the 70% exceedance flows, presently undetermined, are recommended. This information will be available when flow records for the USGS gage near Cameron are summarized.

The instream flows that will maintain a low and high level of aquatic habitat potential in reach #2 of the Madison River are partially identified in Table 4. Instream flows recommended for reach #2 correspond to the high level of aquatic habitat potential. During some months (December through April in particular), the recommended instream flows probably exceed the mean monthly flows. This indicates that any additional depletions during these months could be harmful to the aquatic resource.

Table 3. Approximate distribution of the average daily flows during the approximate 12-month period preceeding the estimates of age I brown trout in a 5 mile section of reach #2 of the Madison River in Fall, 1967 through Fall, 1978.

	AVERAGE DAILY FLOWS (ft ³ /s)												Est. Number Age I Brown trout/5 miles
	450	550	650	750	850	950	1050	1150	1250	1350	1450	1550	
1966-67	0	56	7	1	4	76	7	7	173				1643
1967-68	0	0	0	0	2	19	63	76	175				4410
1968-69	0	0	0	0	0	20	71	34	215				3179
1969-70	0	0	0	0	0	31	115	49	150				3876
1970-71	0	1	0	13	11	14	61	21	231				3689
1971-72	0	0	0	0	0	0	28	34	296				3012
1972-73	0	0	0	0	0	0	48	75	218				3597
1973-74	0	0	0	0	0	26	76	43	195				4013
1974-75	0	0	0	0	0	7	4	85	242				4634
1975-76	0	0	0	0	0	0	17	74	255				7876
1976-77	3	2	7	40	46	2	10	76	157				4332
1977-78	0	0	0	0	13	51	42	15	221				3610

Table 4 . Instream flows representing low and high levels of aquatic habitat potential for reach #2 of the Madison River.

Time Period	Flow			
	Low 1/ CFS	AF	High 2/ CFS	AF
January	650	39,967	1,300	79,934
February	650	37,388	1,300	74,777
March	650	39,967	1,300	79,934
April	650	38,678	1,300	77,355
May 1-15	650	19,339	1,300	38,678
May 16-31	3/		3/	
June 1-15	3/		3/	
June 16-30	3/		3/	
July 1-15	3/		3/	
July 16-31	650	20,628	1,300	41,256
August	650	39,967	1,300	79,934
September	650	38,678	1,300	77,355
October	650	39,967	1,300	79,934
November	650	38,678	1,300	77,355
December	650	39,967	1,300	79,934

1/ Low level of aquatic habitat potential.

2/ High level of aquatic habitat potential.

3/ Flows presently unidentified.

5. REACH #3

From McAtee Bridge to Quake Lake - 27 miles.
(T8S, RLW, Sec. 36 to T11S, R43E, Sec. 36)

Description

Reach #3 lies within the upper Madison Valley. The river is wide and shallow with depths rarely exceeding 4 ft. The river consists primarily of riffle-run areas interspersed with large boulders. The bottom substrate consists primarily of boulders, cobble and gravel. The gradient averages 27 ft per mile. The floodplain is vegetated with grasses mixed with willow, alder and an occasional cottonwood and conifer.

Fishery

Rainbow trout, brown trout, cutthroat trout and mountain whitefish comprise the sport fishery in reach #3. Rainbow trout comprise about 70-85% of the trout population. Trout reach weights up to 5 pounds, but few exceed 1.5 pounds.

Heavy angling pressure, which ranged from 290 to 950 man days per mile of river in 1975, 1976 and 1977, has affected the population of larger trout in reach #3 (Vincent 1976 and 1977). In September 1976, the estimate of numbers of 3 year and older rainbow and brown trout in a study section within reach #3 was 226 and 97, respectively, per mile. This section was closed to fishing in 1977. In September 1977, the estimate of numbers of 3 year and older rainbow and brown trout was 591 and 244, respectively, per mile. Numbers of older rainbow trout increased 162% and those of older brown trout increased 152% after fishing was stopped.

Presently, angling is affecting the population of older trout more severely than are flow variations. As the population in the study section increases following the angling closure, the impact of flows will become more evident.

Catch rates for reach #3, which range from 1.23 to 2.73 trout per hour, are relatively high when compared to other rivers of Montana.

Waterfowl

Waterfowl use the river during spring and fall migration. Nesting waterfowl include Canada geese, mallard, blue-winged teal, and common merganser.

Wildlife

Big game animals using the floodplain are moose, elk and mule deer. Upland game birds include ruffed grouse, blue grouse and Hungarian partridge. Bald and golden eagles are frequently observed in the area.

Methods Used For Flow Recommendations

The wetted perimeter method was used to identify the flows providing a low and high aquatic habitat potential. Five cross-sections, located about 20 miles below Hebgen Dam, were surveyed. The relationship between wetted perimeter and flow for the five cross-sections was generated using the IFG4 computer program.

The data needed to derive flow recommendations for the high water period (May 16 - July 15) are presently unavailable due to the lack of USGS flow records for reach #3. Future flow recommendations during this period will be based on the dominant discharge/channel morphology concept (See page 5).

Flow Recommendations

The relationship between wetted perimeter and flow for a composite of five cross-sections in reach #3 is shown in Figure 6. The two inflection points occur at approximate flows of 600 and 1,300 cfs and correspond to the low and high levels of aquatic habitat potential, respectively (see page 7).

The bankfull flow, presently undetermined, should be established for 24 hours during June. For the remainder of the high water period (May 16 - July 15), the 70% exceedance flows, presently undetermined, are recommended. This information is unavailable due to the lack of USGS gage records for reach #3.

The flows that will maintain a low and high aquatic habitat potential are partially identified in Table 5. Instream flows recommended for reach #3 of the Madison River correspond to a high level of aquatic habitat potential. During some months (December through April in particular), the recommended instream flows probably exceed the mean monthly flows. This indicates that any additional depletions during these months could be harmful to the aquatic resource.

6. REACH #4

From Quake Lake to Hebgen Dam - 1.5 miles.
(T11S, R43E, Sec. 36 to T11S, R44E, Sec. 23)

Description

This short stretch of river lies within a narrow canyon. The river primarily consists of riffle-run areas interspersed with large boulders. Boulders, cobble and gravel comprise the bottom substrate. River banks are primarily vegetated with grass, willow, alder and an occasional conifer.

Fishery

Rainbow trout, brown trout, mountain whitefish and an occasional cutthroat trout comprise the sport fishery in

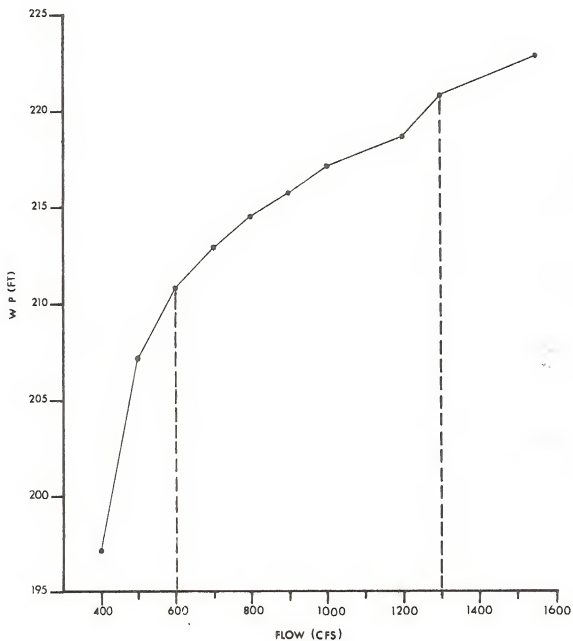


Figure 6 . The relationship between wetted perimeter and flow for a composite of 5 cross-sections in reach #3 (from McAtee Bridge to Quake Lake) of the Madison River.

Table 5. Instream flows representing low and high levels of aquatic habitat potential for reach #3 of the Madison River.

Time Period	Flow			
	Low 1/		High 2/	
	CFS	AF	CFS	AF
January	600	36,893	1,300	79,934
February	600	34,512	1,300	74,777
March	600	36,893	1,300	79,934
April	600	35,702	1,300	77,355
May 1-15	600	17,851	1,300	38,678
May 16-31	3/		3/	
June 1-15	3/		3/	
June 16-30	3/		3/	
July 1-15	3/		3/	
July 16-31	600	19,041	1,300	41,256
August	600	36,893	1,300	79,934
September	600	35,702	1,300	77,355
October	600	36,893	1,300	79,934
November	600	35,702	1,300	77,355
December	600	36,893	1,300	79,934

1/ Low level of aquatic habitat potential.

2/ High level of aquatic habitat potential.

3/ Flows presently unidentified.

reach #4. Trout occasionally reach weights to 4 pounds, but most are in the 10-15 inch class. Scale analyses indicated that many of the trout creelied by anglers in 1977 were part-time residents of Quake Lake. Angling pressure in 1977 was estimated at 1,561 man days per mile and the catch rate was 0.67 trout per hour.

Waterfowl

See reach #3

Wildlife

Big game animals using the river bottom are moose, elk, mule deer and black bear. Upland game birds include blue grouse and ruffed grouse. Bald and golden eagles are commonly observed. Adjacent mountainsides are included in the critical habitat of the grizzly bear, an endangered species in the lower 48 states.

Environmental Concerns

When Hebgen Reservoir is being filled during snow runoff from mid-May through early July, flow releases as low as 50 cfs occur at Hebgen Dam. Since only one tributary (Cabin Creek) enters the river between Hebgen Dam and Quake Lake, the flow in reach #4 is almost entirely dependent on releases at the dam. As a result, reach #4 is severely dewatered from mid-May through early July. The runoff flows of the many tributaries downstream of Quake Lake insure that dewatering does not occur in the remaining 84 miles of the Madison River below reach #4. This water management policy, while jeopardizing the fishery in reach #4, protects the fishery in the rest of the river by allowing greater flow releases from February through April. Since water is not stored during the February through April period, the releases at Hebgen Dam are approximating natural flows. Prior to this water management policy, the reservoir was filled during late winter and early spring. As a result, the entire 85.5 miles of river below Hebgen Dam were severely dewatered from February through April.

Method Used For Flow Recommendations

Flow recommendations are based on the water storage plan for Hebgen Reservoir (see Environmental Concerns).

Flow Recommendations

The present management plan for reach #1, derived through a cooperative agreement between the Montana Power Company, the U.S. Forest Service and the Montana Department of Fish and Game, calls for a minimum flow of 50 cfs when Hebgen Reservoir is filled from May 15 to July 15. The fishery in the 1.5 miles of reach #4 is compromised in order to protect the fishery in the remaining 84 miles of river below Quake Lake (see Environmental Concerns).

1. RIVER

West Gallatin River

2. GENERAL DESCRIPTION

The free-flowing West Gallatin River (Figure 7) originates at Gallatin Lake in Yellowstone National Park at an elevation of 8,834 ft. It flows north for approximately 100 miles to Manhattan, Montana where it joins the East Gallatin River to form the Gallatin River. From the park boundary the river flows about 41 miles through the narrow Gallatin canyon, then enters the broad Gallatin valley where it flows an additional 30 miles to the East Gallatin River.

The West Gallatin River drains an area of 11,000 square miles all above an elevation of 4,000 ft. Most of the drainage basin above 5,000 ft is covered with coniferous forest while the drainage basin below 5,000 ft consists primarily of the Gallatin valley, one of the richest agricultural regions in Montana.

The mean discharge for a 49-year period of record at the USGS gage near the mouth of the canyon (near Gallatin Gateway) was 817 cfs. Discharges ranged from 117 to 9,690 cfs. This gage, which is upstream of all irrigation diversions, reflects the natural flow regime of the river. The high water period normally occurs from late May to late July with peak flows occurring in early June.

There are more than 70 tributaries to the West Gallatin River. Most are relatively unproductive, steep gradient streams having a mean annual flow of a few cfs.

The upper 70 miles of the West Gallatin River are primarily within Yellowstone National Park and the Gallatin National Forest. This section, except for the upper 12 miles, is closely paralleled by U.S. 191 which provides easy access to the river. Dude ranches, lodges, and Forest Service campgrounds are scattered throughout the area. The Big Sky of Montana complex, a large recreational development constructed in the 1970's, exemplifies the growth occurring in the canyon area. The steady rise in recreational and homesite development and tourism is expected to have considerable impact on the canyon area in future years.

The lower 30 miles of river flow primarily through private lands within the Gallatin valley. However, access to the river is readily obtained through some private lands, Fish and Game

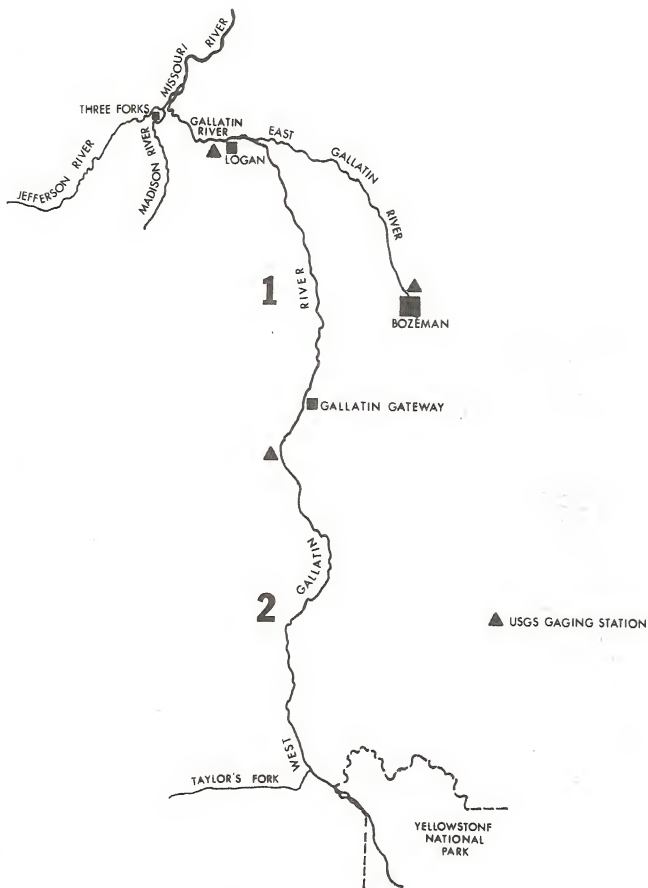


Figure 7. Map of the West Gallatin and Gallatin Rivers.

lands, and at bridge crossings. Fishermen access to the river banks is guaranteed by a local court ruling which declares much of the river navigable.

Bozeman, which is 7 miles from the river at the closest point of contact, is the largest city in the drainage. Between 1971 and 1977, the population of the Bozeman area increased from 24,000 to 31,000 and is expected to reach 106,000 by the year 2,000, making it one of the fastest growing communities in Montana (Blue Ribbons 1978).

The water chemistry of the river has been described by Stuart et al. (1974). In general, the water quality is excellent. The major concerns in regard to water quality are related to the future. A water quality management plan that will preserve and protect the fishery of the Gallatin drainage was completed in 1978 (Blue Ribbons 1978). This plan assesses the impact of development, population growth, and land use practices on water quality in the drainage and recommends ways to alleviate future water quality problems.

Forty-five of the approximate 71 miles of the West Gallatin River outside of Yellowstone National Park are classified as having national as well as statewide fishery value ("Blue Ribbon"). The West Gallatin comprises 11% of Montana's "Blue Ribbon" streams.

The West Gallatin River is heavily utilized by both resident and nonresident anglers. Total fishing pressure in fisherman days was estimated at 42,046 between May 1968 and April 1969 and 44,032 between May 1975 and April 1976 (MDFG 1969 and 1976). Nonresidents comprised 26% of the pressure in 1975-76. Of the 10 major rivers in the upper Missouri drainage in southwest Montana, the West Gallatin ranks third behind the Madison and Big Hole rivers in total fishing pressure. Many factors contribute to its popularity. It is readily accessible to the public, is near a rapidly growing population center, parallels a main route to Yellowstone National Park, and its natural beauty attracts fishermen.

The relatively small size of the river, the many channel obstructions, and easy bank access are primarily responsible for the limited use of the West Gallatin River by float fishermen. However, whitewater kayaking and rafting are popular during spring runoff.

The Montana Department of Fish and Game manages the West Gallatin River as a wild trout fishery. Since 1974 the West Gallatin has not received any supplemental plants of hatchery trout. In the canyon reach, rainbow trout are the dominant trout while brown trout are dominant in the valley. Other game fish present are cutthroat trout, rainbow-cutthroat hybrids, brook trout, and mountain whitefish. Nongame fish include mottled sculpin, longnose sucker, white sucker, mountain sucker, and longnose dace. Growth rates of fish in the drainage are slightly lower than the average for other rivers in southwest Montana (Opheim

and Nelson 1955). The fishery in some of the larger tributaries to the West Gallatin River is described by Vincent (1976).

3. REACH #1

From the junction of the East Gallatin River to the mouth of the Gallatin Canyon.

(T2N, R3E, Sec. 27 to T4S, R4E, Sec. 5)

Description

As the West Gallatin River leaves the canyon, flow is confined to a single channel. Mean channel width at this point is approximately 151 ft. As the river progresses through the valley, the flow becomes braided into 3-4 channels with the main channel shifting from year to year. Mean channel width in the lower valley is approximately 647 ft. The streambed at the mouth of the canyon is approximately 20% boulder, 70% rubble and 10% gravel and sand (FWS 1950). In the lower river, the streambed is approximately 50% rubble and 50% gravel, sand and silt (FWS 1950). Fish cover primarily consists of long, deep pools, log jams, and debris piles. The gradient is approximately 38 ft per mile. The banks are vegetated primarily by cottonwood, willow and alder.

The valley reach (#1) is markedly affected by man, most notably by irrigation diversions. As the river progresses through the valley, water is diverted for agriculture during the summer growing season. The degree of flow reduction (dewatering) depends on the annual discharge with more severe dewatering occurring in low water years. A dewatering survey in the summer of 1966 showed that 12 miles of the valley reach were dewatered over 90% for 3-8 weeks (Wipperman 1967). In some years portions of the lower river are totally dewatered in late July and August (FWS 1950 and Vincent and Nelson 1978).

The water in the valley reach is comparatively cold except in areas subject to extreme dewatering. The highest water temperature recorded in 1976 and 1977 near the canyon mouth was 66 F while temperatures as high as 78F were recorded in dewatered sections of the lower river (Nelson 1977). Temperatures above 70F are considered undesirable for trout.

Fishery

In April 1976 standing crop estimates of age III and older trout per 1,000 ft in the valley reach ranged from 66-153 lbs, while standing crop estimates of age III and older mountain whitefish per 1,000 ft ranged from 255-374 lbs. Number estimates per 1,000 ft ranged from 88-224 for trout and 289-467 for mountain whitefish. In September of 1976 and 1977 standing crop estimates of age II and older trout per 1,000 ft ranged from 95-218 lbs, while standing crop estimates of age III and older mountain whitefish per 1,000 ft ranged from 155-647 lbs. Number estimates

per 1,000 ft ranged from 103-308 for trout and 169-703 for mountain whitefish. Populations of trout and whitefish were highest in the least dewatered sections. Presently, the diversion of water during the summer irrigation season appears to be the major factor limiting standing crops of trout in the valley reach (Vincent and Nelson 1978). While floodplain development, channel stabilization projects, and land use practices are contributing to the decline of the fishery, their present impact is not as severe as dewatering.

The loss of game fish to irrigation diversions is substantial. Clothier (1952) estimated the annual loss for the valley reach at 13,400 game fish weighing 5,600 lbs. This almost equals the fishermen harvest for the valley reach in 1950.

The estimated fishing pressure in fisherman days for the valley reach was 11,000 in 1949, 13,000 in 1950 and 34,781 between May 1975 and April 1976 (FWS 1950 and MDFG 1976). Nonresidents comprised 10-20% of the pressure. Since 1949, fishing pressure has increased threefold. This increase probably reflects the rapidly growing population of the Bozeman area. In 1949 and 1950 an estimated 16,000 fish were creelied in each year with rainbow trout comprising 50-60% of the catch. No harvest estimates are available for recent years. However, electrofishing has shown that brown trout now comprise approximately 90% of the trout population in much of the valley reach. The cause of the apparent shift from rainbow to brown trout in the past 30 years is unknown, but may be related to dewatering.

Waterfowl

Ducks and geese use reach #1 during spring and fall migration. Use of this reach by nesting Canada geese is presently increasing. Other waterfowl nesting along the river include blue-winged teal, mallard and common merganser. Goldeneyes and mergansers commonly winter on the river.

Wildlife

The bottomland along reach #1 supports huntable populations of mule deer, white-tailed deer and various upland game birds including ring-necked pheasant, Hungarian partridge, ruffed grouse, and sharp-tailed grouse. Furbearers include mink, beaver, muskrat, otter, raccoon, red fox and coyote. Bald eagles commonly winter along the river. A great blue heron rookery is located along the river near Belgrade.

Environmental Concerns

Other factors are operating in conjunction with dewatering and the elevated water temperatures associated with dewatering (see Description and Fishery) to depress the fishery in reach #1. The natural tendency of the river channel to migrate within the floodplain affects agricultural lands, pastures, homesites, bridges and irrigation diversions. Various projects including

diking, riprapping, bulldozing of new channels, jetty construction, and the removal of cottonwood snags have been tried or proposed as ways to control the river and protect the floodplain development. While most have been ineffectual in stabilizing the channel, some projects have adversely affected trout habitat.

The natural instability of reach #1 and approaches toward improving the stability are discussed in Blue Ribbons (1977). One approach, which calls for the removal of cottonwood snags within the channel and potential problem trees on the banks, could severely impact the fishery. In addition to causing some lateral movement of the channel during high water periods, snags also provide much of the fish cover in reach #1.

Presently, river migration is threatening Interstate 90 bridges over the West Gallatin River and Baker Creek and adjacent agricultural lands. The river is attempting to capture the Baker Creek channel which parallels the river. Any proposals toward improving the stability of the river should consider the impact on fish habitat.

Water quality problems resulting from the increasing homesite development along the river will undoubtedly be major concerns to the fishery in future years.

Method Used For Flow Recommendations

Biological and flow data were used to identify the flows providing the low and high levels of aquatic habitat potential. In addition, the wetted perimeter method was used. Seven cross-sections near the canyon mouth (about river mile 30) were surveyed. The relationship between wetted perimeter and flow for the seven cross-sections was generated using the IFG4 computer program.

Flow recommendations for the high water period (May 16 - July 15) were based on the dominant discharge/channel morphology concept (see page 5) and obtained from data supplied by the USGS (1975 and 1978). The 14-year frequency peak flow was used to approximate the bankfull flow.

Flow Recommendations

Trout populations in the valley reach (#1) appear to be primarily limited by the magnitude of the flows during the summer months of July, August and September when dewatering occurs (Vincent and Nelson 1978). The least dewatered sections of the valley reach support the highest trout populations (Figure 8). The section having a minimum summer flow of 525 cfs supported about two times the number and biomass of adult trout that occurred in the section having a minimum summer flow of 250 cfs. It appears that summer flows greater than approximately 525 cfs would provide an aquatic habitat capable of supporting the highest populations of trout, while flows less than approximately 250 cfs cause severe reductions in trout populations. It is assumed that the instream flow recommendations derived from this biological data also apply to the nonsummer months.

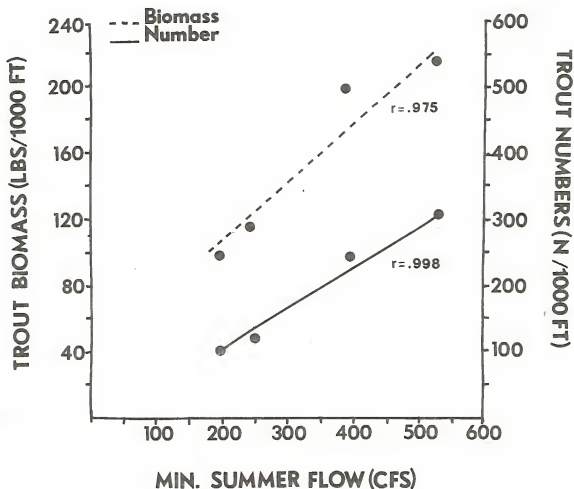


Figure 8. Relationship between the minimum summer flow (ft³/s) and the estimated numbers (N/1000 ft) and biomass (lbs/1000 ft) of age II and older trout in sections of the valley reach of the West Gallatin River in September, 1976 and 1977.

The relationship between wetted perimeter and flow for a composite of seven cross-sections in the valley reach is shown in Figure 9 . The two inflection points occur at approximate flows of 300 and 500 cfs and correspond to the low and high levels of aquatic habitat potential, respectively (see page 7). The instream flows derived from this wetted perimeter method are very similar to those derived from the biological data.

The bankfull flow for the valley reach of the West Gallatin River is about 4,220 cfs. This flow should be established for 24 hours during June 1 - 15. For the remainder of the high water or runoff period (May 16 - July 15), the 70% exceedance flows are recommended (see page 5). The bankfull and 70% exceedance flows were computed from data collected at the USGS gage near Gallatin Gateway. Flows at this gage reflect the natural flow regime of the river.

The instream flows that will maintain a low and high level of aquatic habitat potential are identified in Table 6 . The instream flows recommended for the valley reach (#1) of the West Gallatin River correspond to the high level of aquatic habitat potential and amount to 0.53 MAF per year. For all months, except May, June, July, and August, the recommended flows exceed the mean monthly flows (Table 6). This indicates that water withdrawals from the valley reach (#1) during the months of September through April are potentially harmful to the fishery in most years.

A 1969 state law (Section 89-801, R.C.M. 1947) authorized the Montana Department of Fish and Game to appropriate water for instream uses on 12 rivers in the state. On the upper 12 miles of the valley reach (#1), the department appropriated 400 cfs from September 1 to April 30 and 800 cfs from May 1 to August 31. However, this appropriation has little impact on the fishery since much of the flow in reach #1 is already controlled by the holders of senior water rights. Presently, there is little opportunity for increasing summer flows in reach #1 without constructing storage reservoirs or changing water uses from agricultural to instream.

4. REACH #2

From the mouth of the Gallatin Canyon to the boundary of Yellowstone National Park.
(T4S, R4E, Sec. 5 to T9S, R5E, Sec. 18)

Description

The canyon reach (#2), the "Blue Ribbon" portion of the West Gallatin River, is typical of most high mountain trout streams. Flow is restricted to a single channel which averages approximately 60 ft in width. Gradient is steep, averaging 38 ft per mile. Long riffle areas are common. The streambed is composed primarily of loose boulders, rubble, gravel and sand. Boulders and rubble provide much of the fish cover. The banks are primarily vegetated with conifers, willow and alder. The maximum water temperature is about 66 F.

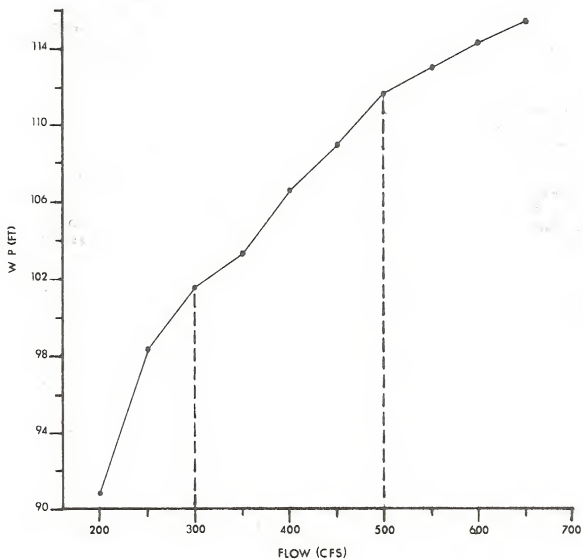


Figure 9. The relationship between wetted perimeter and flow for a composite of 7 cross-sections in reach #1 (from the mouth to the mouth of the Gallatin Canyon) of the West Gallatin River.

Table 6. Instream flows representing low and high levels of aquatic habitat potential compared to mean monthly flows for reach #1 of the West Gallatin River.

Time Period	Flow					
	Low 1/		High 2/		Mean	
	CFS	AF	CFS	AF	CFS	AF
January	250	15,372	525	32,281	307	18,877
February	250	14,380	525	30,198	307	17,659
March	250	15,372	525	32,281	309	19,000
April	250	14,876	525	31,240	480	28,562
May 1-15	250	7,438	525	15,620		
May 16-31	1,579	50,110	1,579	50,110	1,731	106,435
June 1-15	2,379	74,431 ^{2/}	2,379	74,431 ^{3/}		
June 16-30	1,962	58,374	1,962	58,374	2,991	177,977
July 1-15	1,116	33,203	1,116	33,203		
July 16-31	250	7,934	525	16,661	1,323	81,348
August	250	15,372	525	32,281	611	37,569
September	250	14,876	525	31,240	494	29,395
October	250	15,372	525	32,281	461	28,346
November	250	14,876	525	31,240	388	23,088
December	250	15,372	525	32,281	326	20,045
Total		367,358		533,722		588,301

1/ Low level of aquatic habitat potential.

2/ High level of aquatic habitat potential.

3/ Includes a flow of 4,220 cfs for 24 hours.

Fishery

In 1975 the standing crop of trout in the West Gallatin River in the upper canyon was estimated at 38 lbs per 1,000 ft. The estimated number of trout was 90 per 1,000 ft (Vincent 1976). The estimates in 1970 were similar. Preliminary estimates of the number of age II and older rainbow trout in a study section in mid-canyon in April 1978 and September 1978 were 419 and 361 per 1,000 ft, respectively. Limited tag return data collected in 1969-70 suggest that angling has little effect on the existing trout populations in the upper canyon (Vincent 1971). A comprehensive investigation of the effects of angling on trout populations in the canyon reach was initiated in 1978.

The estimated fishing pressure in fisherman days for the canyon reach was 15,000 in 1949, 8,733 in 1971, 10,086 in 1972, and 9,251 between May 1975 and April 1976 (FWS 1950, Lyden 1973, and MDFG 1976). Nonresidents comprised 32-45% of the pressure. The estimated harvest of game fish was 39,000 in 1949, 14,000 in 1971 and 17,000 in 1972. Rainbow trout were the predominant game fish creel in all years. Since 1949, both fishing pressure and harvest have declined in the canyon reach.

Waterfowl

Waterfowl use reach #2 during spring and fall migration. Use of this reach by nesting and wintering waterfowl is limited.

Wildlife

The mountainsides adjacent to the canyon (reach #2) support huntable populations of elk, mule deer, moose, bighorn sheep, mountain goat, black bear, mountain lion, and various game birds, including blue grouse and ruffed grouse. Furbearers include mink, beaver, badger, muskrat, marten, bobcat, lynx, otter, wolverine, red fox and coyote. A portion of the canyon area is included in the critical habitat of the grizzly bear, and endangered species in the lower 48 states. Both golden and bald eagles are commonly observed within the canyon.

Environmental Concerns

A major concern in the canyon area is the heavy sediment input from Taylor's Fork, a tributary to the West Gallatin River. Erosion rates in the Taylor's Fork drainage are naturally high due to its fragile soils. These rates may have been accelerated by logging and grazing. The low trout population in the upper canyon (see Fishery) may partially reflect this sediment problem. Bottom sediments drastically reduce the survival of trout eggs, reduce the numbers and kinds of trout food organisms, and fill in trout habitat.

The canyon reach (#2) maintains nearly all of its flow until it reaches the canyon mouth. Presently, man's impact on the fishery in the canyon area is minimal, but is expected to increase with increased development.

Method Used For Flow Recommendations

The relationship between wetted perimeter and flow was not determined for the canyon reach (#2) of the West Gallatin River. Flow recommendations are based on those for reach #1.

Flow Recommendations

The flows recommended for reach #1 of the West Gallatin River (Table 6) should be delivered to the downstream boundary of reach #2. This recommendation would greatly restrict water withdrawals from reach #2 during the months of September through April in most years. Presently, little water is diverted from reach #2. The relatively natural state of this reach is a major factor contributing to its popularity with recreationists.

A 1969 state law (Section 89-901, R.C.M. 1947) authorized the Montana Department of Fish and Game to appropriate water for instream uses on 12 rivers in the state. On the canyon reach (#2) of the West Gallatin River, the department appropriated 400 cfs from September 1 to April 30 and 800 cfs from May 1 to August 31.

1. RIVER

East Gallatin River

2. GENERAL DESCRIPTION

The free-flowing East Gallatin River originates 0.5 miles north of Bozeman, Montana at the junction of Rocky and Sourdough creeks. It flows about 32.5 miles in a northwesterly direction to Manhattan, Montana where it joins the West Gallatin River to form the Gallatin River (Figure 10).

The river meanders through the Gallatin valley, one of the richest agricultural areas in Montana. Wheat, barley, oats, alfalfa and hay are the major crops. Considerable grazing also occurs. Along the upper river, homesite development is extensive.

The river drains an area of 642 square miles. Gradient averages 16.8 ft per mile. The bottom substrate consists primarily of cobble, gravel and silt. Riparian vegetation, which consists of grasses, willow, alder, chokecherry, cottonwood and various shrubs, has been removed along many portions of the river. As a result, eroding and riprapped banks are common. A serious sediment problem, especially in the lower 15 miles of river, has resulted from man's activities within the valley.

There are about nine major tributaries to the East Gallatin River. Numerous unnamed spring creeks enter the lower 15 miles of river.

The mean flow for a 22-year period of record for the USGS gage near the headwaters (at Bozeman) was 84.6 cfs. Flows ranged from 12 to 1,240 cfs. The high water period generally occurs between April 1 and June 30 and low flows occur between August and March. Little water is diverted from the river during the summer irrigation season.

Water chemistry of the East Gallatin River has been described by Avery (1970), Bahls (1971), Ehlke (1968), Matney (1978), Soltero (1969), Stuart et al. (1974), and Russo and Thurston (1974). In general water quality ranges from poor to good. Sewage effluents from the City of Bozeman raise the nitrate, phosphate and ammonia levels in the upper portion of the river.

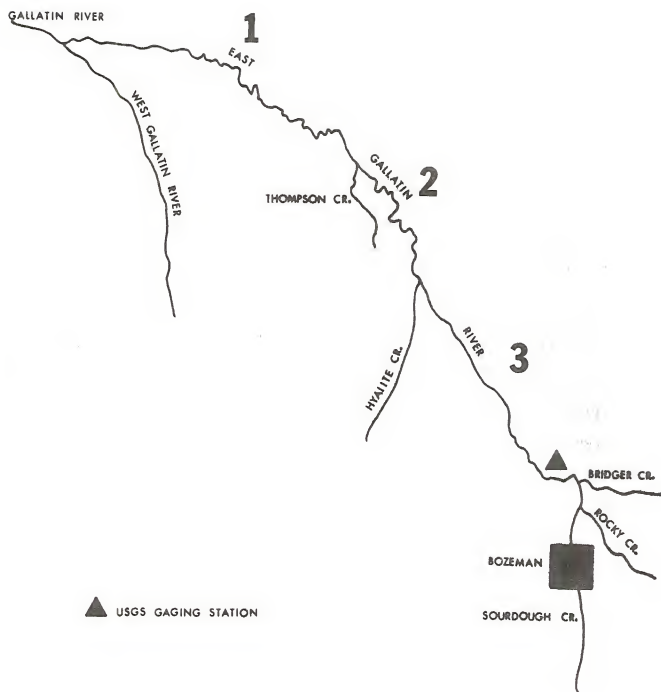


Figure 10. Map of the East Gallatin River.

The sport fishery of the East Gallatin River is classified by the Montana Department of Fish and Game as class 2 or "Red Ribbon." Between April 1975 and May 1976, fishing pressure in fisherman days was estimated at 10,538 (MDFG 1976). Nonresidents comprised 15% of the pressure. The river is managed as a wild trout fishery with no stocking of hatchery trout.

Access to the river is limited since almost all the land adjacent to the river is privately owned. The present landowner attitude allows for reasonable access. In the future, access is expected to be severely limited.

Floating is popular on the East Gallatin River during the fishing and waterfowl seasons.

3. REACH #1

From the junction of the West Gallatin River to the mouth of Thompson Creek - 15.5 miles.
(T2N, R3E, Sec. 27 to T1N, R4E, Sec. 13)

Description

The river in reach #1 meanders through the lower Gallatin valley. The river has a riffle-pool sequence with pools ranging up to 10 ft in depth. Gradient averages 10.7 ft per mile and sinuosity is 1.67. Silt is a major component of the river bottom. The vegetation along the river bank consists of grasses, cottonwood, willow, alder, buffaloberry and various shrubs.

Fishery

Brown trout, rainbow trout, mountain whitefish, and an occasional brook trout comprise the sport fishery in reach #1. Brown trout, the dominant trout species, and rainbow trout occasionally reach weights up to 4-5 pounds, but few exceed 2 pounds. In September 1972, the estimated number of 2 year and older (about 10 inches and larger) trout in a study section within reach #1 was about 909 per mile (Vincent 1976). The estimated biomass of trout was about 724 pounds per mile.

Waterfowl

Waterfowl use the river during spring and fall migration. Canada geese nest along the lower river. Other nesting waterfowl include mallard, blue-winged teal and common merganser. Mergansers and goldeneyes commonly winter on the river.

Wildlife

Big game animals found in the floodplain of the river are mule deer and white-tailed deer. Upland game birds include ruffed grouse, Hungarian partridge and ring-necked pheasant.

Environmental Concerns

The primary concern in reach #1 is the destruction of bank vegetation. The removal of this overhanging vegetation results in the loss of trout cover and increases bank erosion. Bank erosion is contributing to the high water turbidities and excessive sedimentation that occur in reach #1. Bottom sediments decrease the numbers and kinds of trout food organisms, fill in trout habitat, and drastically reduce the survival of trout eggs.

Method Used For Flow Recommendations

The wetted perimeter method was used to identify the flows providing a low and high aquatic habitat potential between June 16 and April 15. Five cross-sections in reach #1 were surveyed. The relationship between wetted perimeter and flow for the five cross-sections was generated using the IFG4 computer program.

Future flow recommendations for the high water period (April 16 - June 15) will be based on the dominant discharge/channel morphology concept (see page 5). The information needed to derive these flow recommendations is presently unavailable due to the lack of USGS flow records for reach #1.

Flow Recommendations

The relationship between wetted perimeter and flow for a composite of five cross-sections in reach #1 is shown in Figure 11. The two inflection points occur at approximate flows of 100 and 200 cfs and correspond to the low and high levels of aquatic habitat potential, respectively (see page 7).

The bankfull flow, presently undetermined, should be established for 24 hours during May. During the remainder of the high water period (April 16 - June 15), the 70% exceedance flows, presently undetermined, are recommended. This information is presently unavailable due to the lack of flow data for reach #1.

The flows maintaining a low and high level of aquatic habitat potential are partially identified in Table 7. The instream flows recommended for reach #1 of the East Gallatin River correspond to the high level of aquatic habitat potential.

4. REACH #2

From the mouth of Thompson Creek to the mouth of Hyalite (Middle) Creek - 5.1 miles.
(T1N, R4E, Sec. 13 to T1N, R5E, Sec. 32)

Description

The East Gallatin River in reach #2 meanders through the Gallatin valley. Gradient averages 15.6 ft per mile and the sinuosity

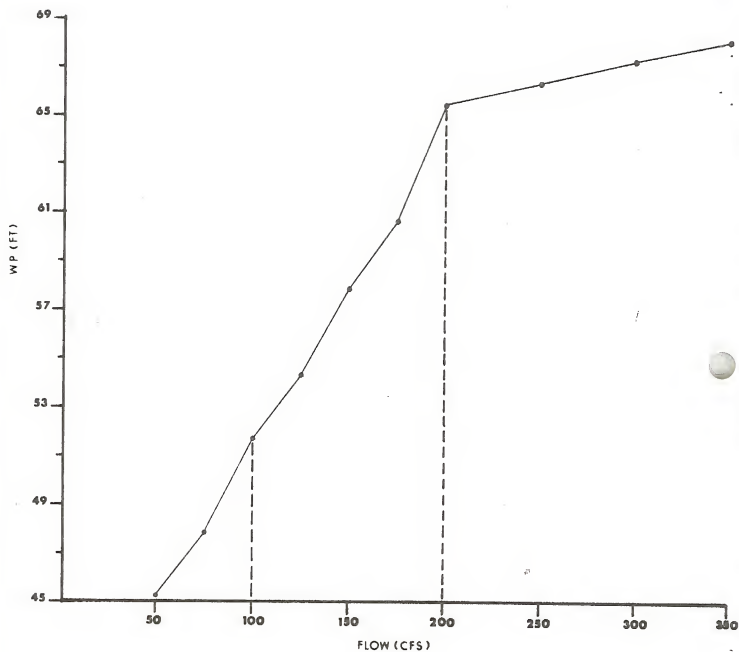


Figure 11. The relationship between wetted perimeter and flow for a composite of 5 cross-sections in reach #1 (from the mouth to Thompson Creek) of the East Gallatin River.

Table 7. Instream flows representing low and high levels of aquatic habitat potential for reach #1 of the East Gallatin River.

Time Period	Flow			
	Low 1/ CFS	AF	High 2/ CFS	AF
January	100	6,149	200	12,298
February	100	5,752	200	11,504
March	100	6,149	200	12,298
April 1-15	100	2,975	200	5,950
April 16-30	3/		3/	
May 1-15	3/		3/	
May 16-31	3/		3/	
June 1-15	3/		3/	
June 16-30	100	2,975	200	5,950
July	100	6,149	200	12,298
August	100	6,149	200	12,298
September	100	5,950	200	11,901
October	100	6,149	200	12,298
November	100	5,950	200	11,901
December	100	6,149	200	12,298

1/ Low level of aquatic habitat potential.

2/ High level of aquatic habitat potential.

3/ Flows presently unidentified.

is 1.94. The river has a riffle-pool sequence with pools ranging up to 8 ft in depth. The bottom substrate is primarily cobble-gravel with silt deposits in the pools. The bank vegetation along portions of this reach has been removed, leaving eroded banks. Rock riprap is also common.

Fishery

Rainbow trout, the dominant trout species, brown trout, mountain whitefish and an occasional brook trout comprise the sport fishery in reach #2. Brown and rainbow trout occasionally reach weights of 4-5 pounds, but seldom exceed 3 pounds. In September 1975, the estimated number of 2 year and older (about 10 inches and larger) rainbow and brown trout in a study section within reach #2 was 530 and 373, respectively, per mile (Vincent 1976). The estimated biomass of trout was 1,162 pounds per mile.

Waterfowl

Same as reach #1.

Wildlife

Same as reach #1.

Environmental Concerns

The destruction of bank and floodplain vegetation and the resulting loss of fish cover and increased soil erosion is also a major concern in reach #2. Water quality is also a major concern. Before the present sewage treatment plant at Bozeman was constructed in 1970, water quality within reach #2 was affected by sewage effluent (Soltero 1968). Vincent (1967) showed that salmonid reproduction within this reach was poor, probably a result of poor water quality. The sewage treatment facility is presently overloaded due to the rapid growth of Bozeman in the past 9 years. Water quality problems are again expected to affect the fishery in reach #2 if new treatment facilities are not provided.

Method Used For Flow Recommendations

The wetted perimeter method was used to identify the flows providing a low and high aquatic habitat potential between June 16 and April 15. Five cross-sections in reach #2 were surveyed. The relationship between wetted perimeter and flow for the five cross-sections was generated using the IFG4 computer program.

Future flow recommendations for the high water period (April 16 - June 15) will be based on the dominant discharge/channel morphology concept (see page 5). The information needed to derive these flow recommendations is presently unavailable due to the lack of USGS flow records for reach #2.

Flow Recommendations

The relationship between wetted perimeter and flow for a composite of five cross-sections in reach #2 is shown in Figure 12. The two inflection points occur at approximate flows of 70 and 150 cfs and correspond to the low and high levels of aquatic habitat potential, respectively (see page 7).

The bankfull flow, presently undetermined, should be established for 24 hours during May. For the remainder of the high water period (April 16 - June 15), the 70% exceedance flows, presently undetermined, are recommended. This information is presently unavailable due to the lack of flow data.

The flows maintaining a low and high level of aquatic habitat potential are partially identified in Table 8. The instream flows recommended for reach #2 of the East Gallatin River correspond to the high level of aquatic habitat potential.

5. REACH #3

From the mouth of Hyalite (Middle) Creek to the origin - 11.9 miles.

(T1N, R5E, Sec. 32 to T1S, R6E, Sec. 31)

Description

The East Gallatin in reach #3 meanders through the upper Gallatin valley. Gradient averages 25.4 ft per mile and sinuosity is 1.32. The river is characterized by a riffle-pool sequence with pools ranging up to 8 ft in depth. The bottom substrate consists of cobble-gravel with deposits of silt and other organic material. Portions of the river bank have been altered, leaving eroded banks. Rock riprap is also common. Much of the floodplain in the Bozeman area has been subdivided for homesite development.

Fishery

Rainbow trout, brown trout and an occasional mountain whitefish, brook trout, cutthroat trout and grayling comprise the sport fishery in reach #3. Rainbow trout, the dominant trout species, and brown trout occasionally reach weights of 3-5 pounds, but few exceed 2 pounds.

In March 1977, the estimated number of 2-year and older rainbow and brown trout in a study section within reach #3 was 685 and 179, respectively, per mile (Vincent and Nelson 1978). The estimated biomass of trout was 596 pounds per mile. In September 1977, the estimated number of 2-year and older rainbow and brown trout was 1,232 and 109, respectively, per mile (Vincent and Nelson 1978). The estimated biomass of trout was 921 pounds per mile. The increase of the rainbow trout population between March and September is discussed in Environmental Concerns.

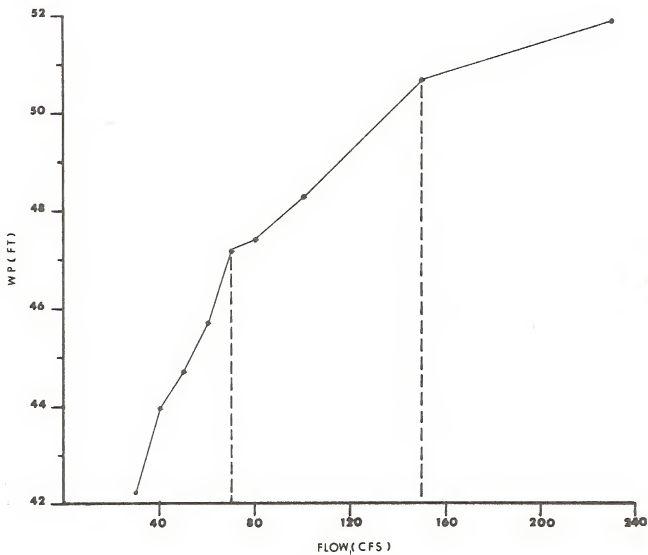


Figure 12. The relationship between wetted perimeter and flow for a composite of 5 cross-sections in reach #2 (from Thompson Creek to Hyalite (Middle) Creek) of the East Gallatin River.

Table 8. Instream flows representing low and high levels of aquatic habitat potential for reach #2 of the East Gallatin River.

Time Period	Flow			
	Low ^{1/}		High ^{2/}	
	CFS	AF	CFS	AF
January	70	4,304	150	9,223
February	70	4,026	150	8,628
March	70	4,304	150	9,223
April 1-15	70	2,083	150	4,463
April 16-30	3/		3/	
May 1-15	3/		3/	
May 16-31	3/		3/	
June 1-15	3/		3/	
June 16-30	70	2,083	150	4,463
July	70	4,304	150	9,223
August	70	4,304	150	9,223
September	70	4,165	150	8,926
October	70	4,304	150	9,223
November	70	4,165	150	8,926
December	70	4,304	150	9,223

^{1/} Low level of aquatic habitat potential.

^{2/} High level of aquatic habitat potential.

^{3/} Flows presently unidentified.

Waterfowl

Same as reach #1 and #2.

Wildlife

Same as reach #1 and #2.

Environmental Concerns

The destruction of bank and floodplain vegetation and the resulting loss of fish cover and increased soil erosion are also a major concern in reach #3. In addition, reach #3 has a serious water quality problem. Bozeman discharges sewage effluent into the river after partial secondary treatment and uses the river to further dilute the effluent in an attempt to meet state water quality standards. In 1973, the discharge for the municipal treatment plant averaged 7.7 cfs from April through September and 5.6 cfs from October through March (Stuart et al. 1974). During the high water months of April, May and June, sewage effluent on the average comprises from 1.9 - 3.3% of the mean monthly flows of the East Gallatin River below the sewage outfall. During July through March, sewage effluent on the average comprises from 6.9 - 12.2% of the mean monthly flows.

Vincent (1978) has shown that the rainbow trout residing in a study section within reach #3 below the sewage outfall move out of the area during the months when the sewage effluent is less diluted, then return during periods of higher river flow.

Sourdough Creek, which flows through the city of Bozeman, has serious water quality problems which it passes on to the East Gallatin River. Storm sewers carry many pollutants into the creek during heavy rains and snow runoff. The poor water quality of this creek decreases the capacity of the East Gallatin River to act as a sewage dilutor.

Method Used For Flow Recommendations

Flow recommendations are based on the flows needed to adequately dilute the sewage effluent from the Bozeman municipal treatment plant and the urban runoff produced by the city of Bozeman.

Flow Recommendations

When considering the present overloaded sewage treatment facility at Bozeman and the population increases predicted in future years, water quality in the East Gallatin River will undoubtedly deteriorate below the present level. To help slow this deterioration and protect the existing salmonid fishery, all existing flow in reach #3 should be used to dilute the pollutants entering the river. On the average, this flow recommendation amounts to 91,897 acre-feet per year (Table 9).

Table 9 . Mean monthly flows for reach #3 of the East Gallatin River.

	Mean <u>1/</u>	
	<u>CFS</u>	<u>AF</u>
January	51.5	3,167
February	56.8	3,267
March	81.2	4,993
April	230.4	13,710
May	401.7	24,700
June	289.7	17,238
July	102.5	6,302
August	63.2	3,886
September	67.2	3,999
October	48.9	3,007
November	66.4	3,951
December	59.8	<u>3,677</u>
Total		91,897

1/ Based on sewage discharges into the East Gallatin River and USGS gage records for the East Gallatin River at Bozeman and Bridger Creek near Bozeman.

1. RIVER

Gallatin River

2. GENERAL DESCRIPTION

The Gallatin River is about 10 miles long from its origin at the confluence of the West and East Gallatin rivers to Three Forks, Montana where it joins the Jefferson and Madison rivers to form the Missouri River (Figure 7). The river flows through a narrow valley consisting of agricultural and grazing lands having an elevation less than 5,000 ft. Flow is confined to one to two channels. The streambed consists primarily of boulders, rubble, gravel and silt. The banks are primarily vegetated with willow and cottonwood. Debris piles, log jams, undercuts and long, deep pools provide much of the fish cover. Except for the East and West Gallatin rivers, tributaries to the Gallatin River are limited to a few spring creeks.

The mean discharge for a 61-year period of record at the USGS gage at Logan was 1,053 cfs. Flows ranged from 130 to 9,840 cfs. Peak flows occur in June. Flows at this gage reflect the dewatering that occurs during the summer irrigation season.

Water quality in the Gallatin River is presently considered good. The river is slightly turbid year-round due to the sediment input from the East Gallatin River. In some summers, dewatering produces undesirable water temperatures.

Access to the river is readily obtained through some private lands, Fish and Game access sites and at bridge crossings. Floating is popular during the fishing and waterfowl seasons.

3. REACH #1

From the mouth to the junction of the West and East Gallatin rivers. Includes the entire length of the river. (T2N, R2E, Sec. 9 to T2N, R3E, Sec. 27)

Description

See GENERAL DESCRIPTION

Fishery

Brown trout is the dominant trout species in the Gallatin River. Other game fish present include rainbow trout and mountain whitefish. Nongame fish present include white sucker, longnose sucker, mottled sculpin, longnose dace, and carp. The river still provides a fair fishery for 1 to 2 pound brown trout in spring, early summer and fall in spite of environmental problems. Brown trout as large as 5-9 pounds are caught annually. The Montana Department of Fish and Game manages the Gallatin River as a wild trout fishery. The river receives no supplemental plants of hatchery trout.

Fishing pressure in fisherman days on the Gallatin River was estimated at 4,118 between May 1968 and April 1969 and 3,918 between May 1975 and April 1976 (MDFG 1969 and 1976). Non-residents comprised about 12% of the pressure in 1975-76. Of the 10 major rivers in the upper Missouri drainage in southwest Montana, the Gallatin ranks ninth in total fishing pressure.

Wildlife

The bottomland along the Gallatin River supports huntable populations of mule deer, whitetail deer, ring-necked pheasant, and Hungarian partridge. Furbearers in the river bottom include beaver, muskrat, mink, otter, raccoon, red fox, and coyote. A great blue heron rookery is located along the river near Logan.

Environmental Concerns

The dewatering of the Gallatin River during July, August, and September is primarily a result of the severe dewatering that occurs in the West Gallatin River, the main tributary to the Gallatin. In some summers, the West Gallatin contributes almost no flow to the Gallatin River. In addition to reducing the amount of living space for trout, dewatering also produces elevated water temperatures. Temperatures above 70 F, which commonly occur in the Gallatin River during summer dewatering, are considered undesirable for trout.

Sedimentation is also a concern. The sediment input from the East Gallatin River and a few small tributaries draining agricultural land is excessive. Bottom sediments drastically reduce the survival of trout eggs, reduce the numbers and kinds of trout food organisms, and fill in trout habitat.

Method Used For Flow Recommendations

The relationship between wetted perimeter and flow was not obtained for the Gallatin River. The flows maintaining a low and high aquatic habitat potential were obtained by adding the values derived for the East and West Gallatin rivers which provide nearly all of the flow in the Gallatin River.

Flow recommendations for the high water period (May 16 - July 15) will be based on the dominant discharge/channel morphology concept (see page 5). The 1½-year frequency peak flow was used to approximate the bankfull flow.

Flow Recommendations

Approximate flows of 350 and 725 cfs will maintain the low and high level of aquatic habitat potential, respectively, in the Gallatin River during July 16 - May 15. During the high water period (May 16 - July 15), the 70% exceedance flows are recommended. This information, which is presently unavailable, will be derived from the flow records for the USGS gage at Logan. The bankfull flow for the Gallatin River is about 4,027 cfs. This flow should be established for 24 hours during June 1-15.

The instream flows that will maintain a low and high aquatic habitat potential are partially identified in Table 10. Instream flows recommended for the Gallatin River correspond to the high level of aquatic habitat potential. During January, February and September the recommended instream flows slightly exceed the mean monthly flows (Table 10). The recommended instream flow for July greatly exceeds the mean monthly flow. The mean flows for July, August and September reflect the dewatering that occurs during the summer irrigation season.

A 1969 state law (Section 89-801, R.C.M. 1947) authorized the Montana Department of Fish and Game to appropriate water for instream uses on 12 rivers in the state. On the Gallatin River, the department appropriated 800 cfs from September 1 - April 30 and 1,500 cfs from May 1 - August 31.

Table 10. Instream flows representing low and high levels of aquatic habitat potential compared to mean monthly flows for the Gallatin River.

Time Period	Flow					
	Low 1/		High 2/		Mean	
	CFS	AF	CFS	AF	CFS	AF
January	350	21,521	725	44,578	684	42,057
February	350	20,132	725	41,702	704	40,495
March	350	21,521	725	44,578	788	48,452
April	350	20,826	725	43,140	1,034	61,527
May 1-15	350	10,413	725	21,570		
May 16-31	3/		3/		2,081	127,956
June 1-15	3/		3/			
June 16-30	3/		3/		2,962	176,251
July 1-15	3/		3/			
July 16-31	350	11,107	725	23,008	960	59,028
August	350	21,521	725	44,578	472	29,022
September	350	20,826	725	43,140	645	38,380
October	350	21,521	725	44,578	752	46,239
November	350	20,826	725	43,140	809	48,139
December	350	21,521	725	44,578	749	46,054
Total						763,600

1/ Low level of aquatic habitat potential.

2/ High level of aquatic habitat potential.

3/ Flows not presently identified.

1. RIVER

Beaverhead River

2. GENERAL DESCRIPTION

The Beaverhead River is 69 miles long from its source at the outlet of Clark Canyon Reservoir, an irrigation storage facility constructed in 1964, to Twin Bridges, Montana where it joins the Big Hole River to form the Jefferson River (Figure 13). From Clark Canyon Dam the river flows about 16 miles through a canyon, then enters the broad, open Dillon valley where it flows an additional 30 miles. At Point of Rocks the river passes through a narrow constriction and continues about 20 miles through a wide, gently sloping valley to its confluence with the Big Hole River.

The river drains an area of approximately 5,000 square miles. A large portion of the drainage consists of rugged mountains ranging from 9,000 to 11,000 ft in elevation. The river elevation at the dam outlet is 5,450 ft and at the mouth is 4,600 ft.

Dillon, with a population of 5,000, is the largest community in the drainage. Butte, one of the largest cities in southwest Montana with a population of 24,000, is about 70 miles from the Beaverhead River at the nearest point of contact. Livestock production is the most important industry in the drainage and hay the most important crop.

Throughout much of its length, the river is confined to a single channel. Mean channel widths range from about 83 ft near the dam to about 93 ft near the mouth. The gradient is gentle, averaging 12 ft per mile. Willow is the dominant bank vegetation. In the upper river, the streambed consists primarily of rubble, gravel, and sand. In addition to the above, silt is a common component of the streambed in the lower river. Fish cover primarily consists of submerged and overhanging bank vegetation, undercuts, and long, deep pools.

Smith (1973) evaluated the effects of Clark Canyon Reservoir on some chemical characteristics of the Beaverhead River. He concluded that critically low dissolved oxygen due to bottom releases from the reservoir is not likely to become a problem in the river. Compared to the reservoir tributaries, ammonia, nitrite, and pH in the tailwaters increased sufficiently to be considered changed by the reservoir.

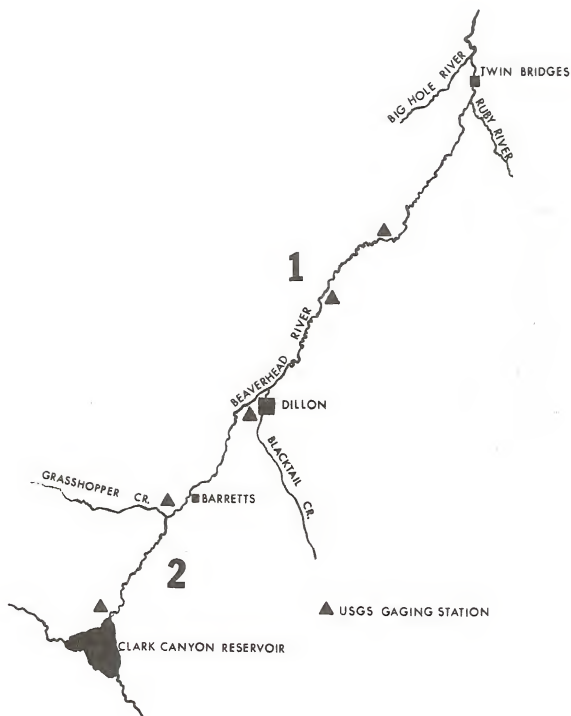


Figure 13. Map of the Beaverhead River.

The water in the Beaverhead River is comparatively cold except in areas subject to extreme dewatering. Temperatures as high as 76.5 F have been recorded in dewatered sections (Nelson 1977). Temperatures above 70 F are generally considered undesirable for trout.

The mean discharge for a 70-year period of record at the USGS gage located about 15 miles below Clark Canyon Dam (at Barretts) was 424 cfs. Discharges ranged from 69 to 2,720 cfs. The peak flows occur in late May to mid June. Since 1964, flows at this gage reflect regulation by Clark Canyon Dam.

The mean discharge for a 41-year period of record at the USGS gage located about 52 miles below Clark Canyon Dam (near Twin Bridges) was 415 cfs. Discharges ranged from 7 to 3,130 cfs. Peak flows occur in late April to early May. Flows at this gage reflect both regulation by Clark Canyon Dam and upstream withdrawals of water during the spring and summer irrigation season. Short-term flow data are also available for USGS gaging sites located 0.4 miles below Clark Canyon Dam (near Grant), at Dillon, and near Dillon.

Clark Canyon Reservoir and irrigation diversions affect the flow pattern in the river. From October through March, Clark Canyon Reservoir stores water for the upcoming irrigation season, therefore, releases into the river are minimal during this period. Irrigation releases occur from April through September. The diversion of irrigation water begins about 15 miles below the dam. The major impact of the reservoir on the upper 15 miles of river was to extend the high water period an additional 5 months from April through September. This extension occurs at the expense of October through March flows. The extension of the high water period has also accelerated channel erosion in the upper river.

Much of the lower river was severely dewatered prior to the construction of the reservoir. In general, the reservoir has provided higher flows in the lower river during the preimpoundment low flow months of May, July, August and September. However, much of the lower 54 miles of river are still severely dewatered during the spring and summer irrigation season. In recent years, sections of the lower river have been totally dewatered (Nelson 1977). The massive withdrawals of irrigation water have essentially eliminated high water flows in the lower river.

The Beaverhead River primarily flows through private lands. Access to the river is readily obtained through some private lands, Fish and Game access sites, and at bridge crossings. Floating is popular during the fishing and waterfowl seasons.

Brown trout are the dominant trout in the Beaverhead River except in the upper 2 miles where rainbow trout dominant. Other game fish present include mountain whitefish and burbot. Nongame fish present include mottled sculpin, white sucker, longnose sucker, mountain sucker, longnose dace, and carp. Carp are common in the

lower 20 miles of river and uncommon elsewhere. The Montana Department of Fish and Game manages the Beaverhead River as a wild trout fishery. The river receives no supplemental plants of hatchery trout.

The growth of trout, particularly rainbow trout, in the upper river is exceptional when compared to other rivers of Montana. During a 10-year study of the fishery, age I, II, III and IV and older rainbow trout in the upper river averaged 1.08, 2.46, 4.05 and 5.34 pounds, respectively, with specimens as large as 13.25 pounds captured (Nelson 1977). Due to the exceptional growth and excellent trout cover, the upper 8 miles of river produce a trophy rainbow trout fishery of national acclaim. Maintenance of this trophy fishery depends on adequate flow releases from Clark Canyon Dam during the October through March storage period (Nelson 1977). During the 10-year fishery study, mean flows during the October through March period ranged from 97 to 467 cfs and the annual mortality of older rainbow trout ranged from 28 to 94%. The highest mortalities occurred when October through March flows were lowest.

Trout populations rapidly decline between the upper and lower Beaverhead River. In a series of nine study sections in spring 1976, standing crop estimates of adult trout per 1,000 ft ranged from 46 pounds in the lower river to 794 pounds in the upper river (Nelson 1977). Estimated numbers of adult trout per 1,000 ft ranged from 50 to 486. Estimated standing crops of trout per 1,000 ft have been as low as 30 pounds in the lower river (in August 1971) and as high as 830 pounds in the upper river (in March 1977).

Nelson (1977) concluded that other factors, notably sedimentation, the removal of streambank vegetation, and metals pollution, were operating in conjunction with flow reductions to limit trout populations in the lower river. Of these factors, sedimentation is a major concern. Sediment transport in the river is hindered by the diversion of reservoir releases for irrigation. The removal of large amounts of water reduces water velocity to a point where sediments can no longer remain suspended and, therefore, are deposited in the lower river. Bottom sediments drastically reduce the survival of trout eggs, reduce the numbers and kinds of trout food organisms, and fill in trout habitat. An annual high water period, which has essentially been eliminated by massive irrigation withdrawals, is needed to flush bottom sediments and maintain channel morphology. The restoration of an annual high flow period is essential for improving the fishery of the lower river.

Grasshopper and Blacktail creeks and irrigation return flows from the East Bench irrigation project are major sources of sediment to the Beaverhead River.

Trout food organisms are more abundant in the upper river. Smith (1973) found a substantial increase in zooplankton immediately below the dam and speculated that this increase may provide

additional food for small trout through the first 6 miles of river below the reservoir. Limited bottom sampling in 1975 showed a much greater abundance of aquatic invertebrates in the riffles of the upper 15 miles of river (Nelson 1977). The extremely high productivity of the upper river is probably related to Clark Canyon Reservoir while the limited productivity of the lower river reflects complex environmental problems.

Of the 10 major rivers in the upper Missouri drainage in southwest Montana, the Beaverhead River ranks fifth behind the Madison, Big Hole, West Gallatin, and Jefferson rivers in total fishing pressure. Total fishing pressure in fisherman days was estimated at 14,152 between May 1975 and April 1976 (MDFG 1976). Nonresidents comprised 26% of the total pressure. Fishing pressure in fisherman hours in the upper 52 miles of river was estimated at 30,248 in 1971 and 37,072 in 1972 (MDFG 1975). The estimated catch of trout in the upper 22 miles of river was 10,297 in 1971 and 11,378 in 1972. The average size of the brown trout creel in the upper river in 1972 was 14.8 inches while the average size of the rainbow trout creel was 15.0 inches. In the lower river, the average size of the brown and rainbow trout creel was 13.6 inches. Catch rates were estimated at .38 and .36 trout per hour in 1971 and 1972, respectively.

Due to its high fishery, scenic and recreational value, the upper 12 miles of the Beaverhead River qualify for "Blue Ribbon" status.

3. REACH #1

From the mouth to the Barretts diversion dam.
(T3S, R6W, Sec. 21 to T8S, R9W, Sec. 17)

Description

See GENERAL DESCRIPTION

Fishery

See GENERAL DESCRIPTION

Waterfowl

Waterfowl use the river during spring and fall migration. Use of reach #1 by nesting Canada geese is limited. Other nesting waterfowl include blue-winged teal, mallard, and common merganser. Goldeneyes and mergansers commonly winter on the river.

Wildlife

The bottomland along reach #1 supports huntable populations of mule deer, white-tailed deer, ring-necked pheasant, and Hungarian partridge. Elk, moose, and black bear are hunted in the surrounding mountains. Furbearers along the river include

beaver, muskrat, mink, otter, red fox, and coyote. Bald eagles commonly winter along the river.

Environmental Concerns

In addition to sedimentation, dewatering, and the elevated water temperatures associated with dewatering (see GENERAL DESCRIPTION), other environmental problems occur in reach #1. Mercury pollution has been documented in the vicinity of Dillon. Some fish in this area contain mercury greatly in excess of FDA standards. Possible sources of mercury are natural spring discharges, seed-potato treatment, the leaching of old mill tailings, and industrial activity. Water quality is also threatened by the increasing homesite development occurring along the river and discharges from the outdated sewage treatment facility at Dillon.

Man's increasing activity in the river bottom is also a concern. The removal of bank vegetation through pasture and homesite development and overgrazing is increasing rates of soil erosion and decreasing the amount of trout cover. Much of the trout cover in reach #1 is provided by overhanging and submerged bank vegetation. Removal of this cover reduces the capacity of the river to support trout.

Method Used For Flow Recommendations

The wetted perimeter method was used to identify the flows providing a low and high aquatic habitat potential. Eleven cross-sections, located about 52 miles below Clark Canyon Dam, were surveyed. The relationship between wetted perimeter and flow for the 11 cross-sections was generated using the WSP computer program.

The data needed to derive flow recommendations for the high water or runoff period (approximately May 16 - July 15) are presently unavailable. This data will be available when flow records for the USGS gage near Twin Bridges are summarized. Future flow recommendations during this period will be based on the dominant discharge/channel morphology concept (see page 5).

Flow Recommendations

The relationship between wetted perimeter and flow for a composite of 11 cross-sections in reach #1 is shown in Figure 14. The two inflection points occur at approximate flows of 150 and 350 cfs and correspond to the low and high levels of aquatic habitat potential, respectively (see page 7).

During the high water period (approximately May 16 - July 15), the bankfull flow should be established for 24 hours. Flows resembling the natural hydrograph should be provided for the remainder of the high water period. However, the 70% exceedance flows established for the USGS gage near Twin Bridges may not be sufficient. Data for this gage does not reflect the natural high flow period because massive upstream water withdrawals have occurred throughout the period of record.

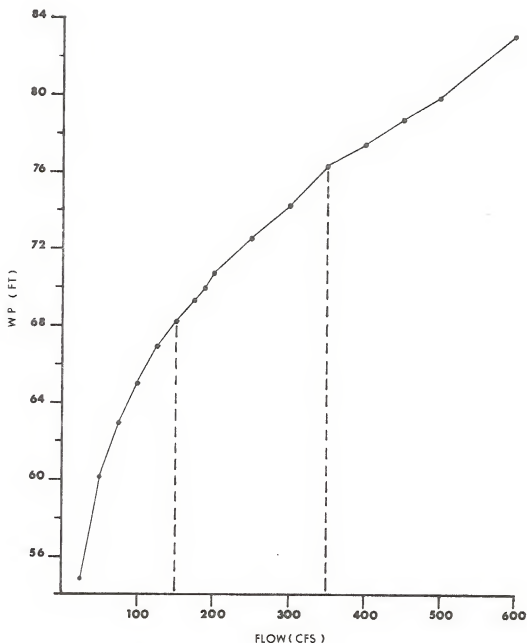


Figure 14. The relationship between wetted perimeter and flow for a composite of 11 cross-sections in reach #1 (from the mouth to the Barretts Diversion Dam) of the Beaverhead River.

The flows maintaining a low and high level of aquatic habitat potential are partially identified in Table 11. The instream flows recommended for reach #1 of the Beaverhead River correspond to the high level of aquatic habitat potential. The recommended instream flows greatly exceed the minimum flow of 25 cfs provided for fish and wildlife benefits by the Clark Canyon project.

4. REACH #2

From the Barretts diversion dam to Clark Canyon Dam.
(T8S, R9W, Sec. 17 to T9S, R10W, Sec. 32)

Description

See GENERAL DESCRIPTION

Fishery

See GENERAL DESCRIPTION

Waterfowl

Waterfowl use reach #2 during spring and fall migration. Nesting waterfowl include blue-winged teal, mallard, and common merganser. Goldeneyes and mergansers commonly winter on the river.

Wildlife

The bottomland along reach #2 supports huntable populations of mule deer, whitetail deer, ruffed grouse, and Hungarian partridge. Elk, moose, and black bear are hunted in the surrounding mountains. Furbearers along the river include beaver, muskrat, mink, otter, red fox, bobcat and coyote. Bald eagles commonly winter along the river.

Environmental Concerns

Flow is an important factor influencing the fishery in reach #2. The trophy rainbow trout fishery depends on adequate flow releases from Clark Canyon Dam during the October through March storage period (see GENERAL DESCRIPTION). There is evidence suggesting the pattern and magnitude of the flow releases during the brown and rainbow trout spawning periods affect reproductive success in the upper river (Nelson 1977). These impacts on the fishery should be considered in the flow management plan for the reservoir.

Water quality in portions of reach #2 has been a concern in past years. Fish kills attributed to toxic concentrations of hydrogen sulfide in reservoir releases occurred in 1965 and 1967 in the upper 1.5 to 3.0 miles of river. Ammonia levels have also been elevated in reach #1. High metal concentrations and turbidities have occurred in the river below Grasshopper Creek, a tributary severely impacted by past mining activity. The extent and severity of water quality problems in recent years is unknown.

Table 11. Instream flows representing low and high levels of aquatic habitat potential for reach #1 of the Beaverhead River.

Time Period	Flow			
	Low 1/ CFS	AF	High 2/ CFS	AF
January	150	9,223	350	21,521
February	150	8,628	350	20,132
March	150	9,223	350	21,521
April	150	8,926	350	20,826
May 1-15	150	4,463	350	10,413
May 16-31	3/		3/	
June 1-15	3/		3/	
June 16-30	3/		3/	
July 1-15	3/		3/	
July 16-31	150	4,760	350	11,107
August	150	9,223	350	21,521
September	150	8,926	350	20,826
October	150	9,223	350	21,521
November	150	8,926	350	20,826
December	150	9,223	350	21,521

1/ Low level of aquatic habitat potential.

2/ High level of aquatic habitat potential.

3/ Flows presently unidentified.

Man's increasing activity in the river bottom is a concern. The removal of bank vegetation through pasture and homesite development and overgrazing is increasing rates of soil erosion and decreasing the amount of trout cover. The high populations of trout throughout much of reach #2 can be attributed to the exceptional trout cover primarily provided by submerged and overhanging willows.

The impact of vegetation removal on trout populations is demonstrated in the upper 2 miles of reach #2. Much of this section was rechanneled during highway construction. This section lacks the heavy willow cover that characterizes an adjacent, unaltered downstream section. In 1976, the estimated number and biomass of trout per 1,000 ft in the rechanneled section were 28 and 39%, respectively, of those in the unaltered section.

Method Used For Flow Recommendations

Biological and flow data were used to identify the flows providing the low and high levels of aquatic habitat potential. In addition, the wetted perimeter was used. Seven cross-sections, located about 2 miles below Clark Canyon Dam, were surveyed. The relationship between wetted perimeter and flow for the seven cross-sections was generated using the IPG4 computer program.

Instream flows for the high water period (May 16 - July 15) were based on the dominant discharge/channel morphology concept (see page 5) and obtained from data supplied by the USGS (1975 and 1978). The 1½-year frequency peak flow was used to approximate the bankfull flow.

Flow Recommendations

The trophy rainbow trout fishery in the upper 8 miles of the Beaverhead River depends on adequate flow releases from Clark Canyon Dam during the October through March storage period. During a 10-year study of the fishery (Nelson 1977), the mortality of the older, trophy size rainbow trout during an approximate 12-month period preceding the fall population estimates was related to the number of average daily flows less than 150 cfs (Figure 15). Annual mortality rates increased as the number of average daily flows less than 150 cfs increased. During the study, the estimated number of trophy (age IV and older) rainbow trout was highest (60 per 6,455 ft) following the 12-month period in which 98.0% of the average daily flows exceeded 300 cfs. The lowest estimate (4 per 6,455 ft) followed a 12-month period in which 54.0% of the average daily flows were less than 150 cfs. Nelson (1977) concluded that flows greater than approximately 250 cfs would provide a high quality, trophy rainbow fishery in the upper river while flows less than 150 cfs produced elevated mortalities of trophy trout.

The relationship between wetted perimeter and flow for a composite of seven cross-sections in reach #2 is shown in Figure 16. The two inflection points occur at approximate flows of 150 and 225 cfs and correspond to the low and high levels of aquatic habitat

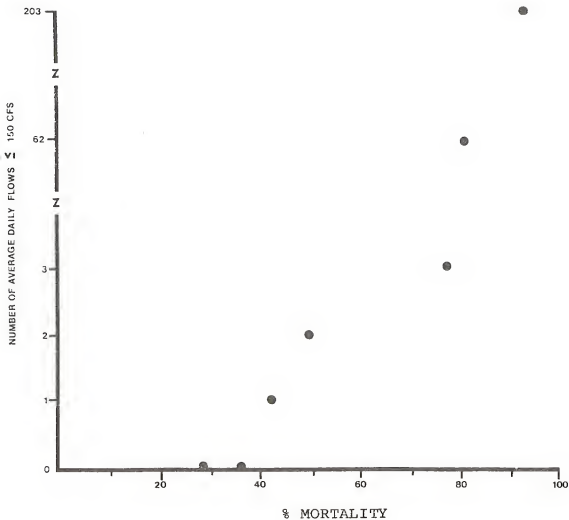


Figure 15. Relationship between the annual mortality (%) of age III and older rainbow trout in the Beaverhead River and the number of average daily flows \leq 150 cfs.

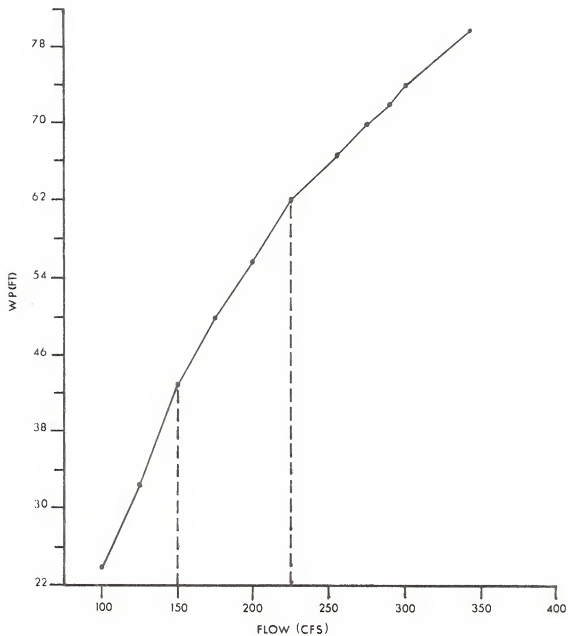


Figure 16. The relationship between wetted perimeter and flow for a composite of 7 cross-sections in reach #2 (from the Barretts Diversion Dam to Clark Canyon Dam) of the Beaverhead River.

potential, respectively (see page 7). The instream flows derived from this wetted perimeter method are very similar to those derived from the biological data.

The bankfull flow for reach #2 of the Beaverhead River is about 1,035 cfs. This flow should be established for 24 hours during June 1 - 15. For the remainder of the high water period (May 16 - July 15), the 70% exceedance flows are recommended (see page 5). The bankfull and 70% exceedance flows were computed from data collected at the USGS gage at Barretts.

The instream flows that will maintain a low and high aquatic habitat potential are identified in Table 12. The instream flows recommended for reach #2 of the Beaverhead River correspond to the high level of aquatic habitat potential and amount to 0.19 MAF per year. For all months, the mean monthly flows in reach #2 exceed the recommended instream flows (Table 12). The recommended instream flows greatly exceed the minimum flow of 25 cfs provided for fish and wildlife benefits by the Clark Canyon project.

Table 12. Instream flows representing low and high levels of aquatic habitat potential compared to mean monthly flows for reach #2 of the Beaverhead River.

Time Period	Flow					
	Low 1/		High 2/		Mean	
	CFS	AF	CFS	AF	CFS	AF
January	150	9,223	250	15,372	296	18,200
February	150	8,628	250	14,380	290	16,681
March	150	9,223	250	15,372	345	21,213
April	150	8,926	250	14,876	479	28,502
May 1-15	150	4,463	250	7,438		
May 16-31	274	8,696	274	8,696	619	38,061
June 1-15	387	12,799 ^{3/}	387	12,799 ^{3/}		
June 16-30	345	10,264	345	10,264	780	46,413
July 1-15	304	9,045	304	9,045		
July 16-31	150	4,760	250	7,934	477	29,330
August	150	9,223	250	15,372	401	24,657
September	150	8,926	250	14,876	335	19,934
October	150	9,223	250	15,372	385	23,673
November	150	8,926	250	14,876	420	24,992
December	150	9,223	250	15,372	353	21,705
Total		131,548		192,044		313,361

1/ Low level of aquatic habitat potential.

2/ High level of aquatic habitat potential.

3/ Includes a flow of 1,035 cfs for 24 hours.

1. RIVER

Big Hole River

2. GENERAL DESCRIPTION

The Big Hole River arises in the Bitterroot Mountains of southwest Montana near the town of Jackson. Flowing through a deep mountain valley or hole, as the Nez Perce and early trappers called it, the river receives tributary streams from the Bitterroot and Pioneer Mountain ranges. The river flows approximately 113 miles before it is joined by the Beaverhead and Ruby rivers to form the Jefferson River near Twin Bridges, Montana (Figure 17). From the high mountain meadows of its headwaters to the cottonwood bottoms of the lower valley, the Big Hole is free-flowing and one of the most scenic rivers in Montana.

Average discharge in the Big Hole River from 1924-1977 as measured at the USGS gaging station near Melrose was 1,157 cfs. Extremes for the period of record since the failure of the Wise River Dam in 1927 have been a maximum of 14,300 cfs on June 10, 1972 and a minimum of 49 cfs on August 17, 1931.

Historically, the Big Hole supported populations of cutthroat trout, grayling, mountain whitefish, burbot (ling), longnose dace, mottled sculpin and three species of sucker. Brook, rainbow and brown trout have been introduced to the river. Today the cutthroat have all but disappeared from the river, victims of dewatering and competition from introduced species. Grayling remain in small numbers in the upper river and represent the only major stream-dwelling population in the contiguous United States south of Alaska.

Irrigated hay lands and cattle ranches occupy the entire river valley. During low water years, the dewatering of the river for irrigation can be severe. Dewatering can have adverse effects on fish populations by reducing habitat, food supply, and increasing summer water temperatures.

Water quality can generally be described as excellent throughout the river although it is adversely affected by dewatering as indicated by increased water temperatures and associated decreases in dissolved oxygen concentrations.

The Big Hole River has long been nationally famous for its trout fishery. Large trout have made the river famous, especially from Divide to the river's mouth. In 1959, this 40-mile section of river was given "Blue Ribbon" status in recognition of its

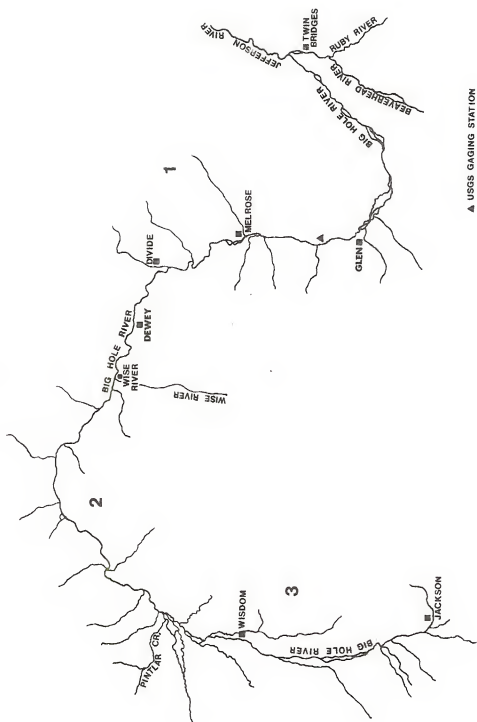


Figure 17. Map of the Big Hole River.

national importance as a fishery. From May 1975 through April 1976, the river provided over 66,000 fisherman days of recreation (MDFG 1976). Of the 10 major rivers in the upper Missouri drainage of southwest Montana, the Big Hole ranks second behind the Madison River in total fishing pressure. Nonresidents comprised nearly 20 percent of the fishing pressure in 1975-76.

Many species of wildlife also depend on the Big Hole River. Moose may be found in the riparian willows along the upper river, while whitetail and mule deer thrive along the riparian zone of the lower river. River otter, beaver, mink and muskrat depend on the river for their survival. Bobcat and coyote are found in the riparian zone of the lower river. The river furnishes resting and breeding areas for many species of ducks and Canada geese. Ospreys nest along the river. Bald eagles have been observed fishing in the river.

3. REACH #1

From the mouth of the Big Hole River to the site of the old Divide Dam.
(T3S, R6W, Sec. 21 to R1S, R10W, Sec. 11)

Description

This "Blue Ribbon" reach of the river is approximately 40 miles long. The lower 30 miles are fairly typical of a river crossing an erodible floodplain. The river meanders through cottonwood lined banks and in many places breaks up into more than one channel, creating islands. The riparian zone of the floodplain is made up of cottonwood, willow, rose and other deciduous shrubs. All of these are important in providing streambank stability and overhanging cover for fish.

The substrate of the river is generally of a gravel to cobble nature. Finer materials are found in deposition areas such as the inside of bends and pools.

The average gradient from the Divide Dam site to the mouth is approximately 14 feet per river mile. Stream width varies with location and flow but is generally in excess of 125 feet and may exceed 225 feet in places at high flows.

Natural flow varies from year to year depending on climatic conditions with peak annual flows corresponding to peak snowpack runoff and occurring in late May or June. Low flow generally occurs in late August or September and flow remains fairly low until the onset of runoff in late March or April of the following year.

Sediment loads tend to vary with flow with peak loads usually occurring with peak flows. In general, sediment loads are presently not a major problem in reach #1.

Research concerning water quality, primary production and macro-invertebrates has been carried out by the Water Quality Bureau of the Montana Department of Health and Environment Sciences (Bahls 1978).

Fishery

Fisheries biologists from the Montana Department of Fish and Game have conducted research on reach #1 of the river since the late 1950's. Early work described the change in fish populations following the introduction of exotic species. Cutthroat trout had all but disappeared from reach #1 by 1959, victims of dewatering and competition from exotic species (Heaton 1960). Fishermen logs from 1954-1963 indicated that brown trout dominated the creel as early as 1955 and electrofishing indicated that they made up the bulk of the trout population by 1962 despite the annual stocking of up to 53,000 catchable, hatchery rainbow trout in this reach (Wipperman 1965).

Brown Trout

Brown trout population estimates made in a 22,500 ft section of the Big Hole River near Melrose from 1969-1971 and 1977 are shown in Table 13 (Elser and Marcoux 1971 and 1972; Peterson 1973; and Wells and Nelson 1978).

Table 13. Comparisons of estimated numbers of age II and older wild brown trout per 1,000 ft in reach #1 of the Big Hole River from September 1969 to April 1971 and April 1977. Pounds per 1,000 ft in parenthesis.

<u>Numbers of Brown Trout</u>				
<u>Sept.1969</u>	<u>April 1970</u>	<u>Sept.1970</u>	<u>April 1971</u>	<u>April 1977</u>
86 (119)	79 (106)	96 (122)	82 (105)	124 (114)

The brown trout population in this section fluctuated somewhat from 1969-71, but has responded favorably to the exceptionally high water years of 1975-76 as indicated by the increase in numbers in April 1977. These two consecutive high water years increased habitat and, therefore, survival of brown trout.

Brown trout numbers have also been enumerated further downstream below the proposed Reichle Dam site (Peterson 1973, 1974a, 1975). This section supported between 120 and 150 age II and older brown trout per 1,000 ft of river between 1971 and 1974.

In general, the brown trout population in reach #1 of the river is a healthy one characterized by the presence of large numbers of 18 inch and larger trout in comparison to most other rivers of Montana.

Rainbow Trout

Catchable size hatchery rainbows were planted extensively in reach #1 from 1954-1974. As a result of low survival of these fish (Elser and Marcoux 1970) and stresses imposed on wild trout by their introduction, planting was curtailed in 1974. Reach #1 is now managed for wild rainbow trout.

Population estimates of wild rainbow trout for the study section near Melrose from 1969-1971 and 1977 are shown in Table 14 (Elser and Marcoux 1971 and 1972; Peterson 1973; and Wells and Nelson 1978).

Table 14. Comparisons of estimated numbers of age II and older wild rainbow trout per 1,000 ft in reach #1 of the Big Hole River from September 1969 to April 1971 and April 1977. Pounds per 1,000 ft in parenthesis.

<u>Numbers of Rainbow Trout</u>				
<u>Sept. 1969</u>	<u>April 1970</u>	<u>Sept. 1970</u>	<u>April 1971</u>	<u>April 1977</u>
35 (29)	39 (42)	36 (26)	38 (35)	27 (26)

Numbers of wild rainbow trout have remained fairly low throughout the 1969-1977 period. The failure of the rainbow population to respond to the high water years of 1975-76 may be due to their numbers being too low to show a rapid response. Rainbow trout appear to be severely affected by dewatering in the Big Hole River, a phenomenon that has also been observed on the West Gallatin and Beaverhead rivers of southwest Montana (Wells 1977 and Nelson 1977).

Other Species

While population estimates have not been made for mountain whitefish in reach #1, they are the most numerous game fish. These fish provide an unexploited winter fishery for their enthusiasts. A new state record whitefish (4.46 pounds) was captured in this reach during electrofishing work in the fall of 1978. Grayling and brook trout are found in very low numbers while burbot are fairly common. Cutthroat trout are extremely rare. Other species found include carp, longnose dace, mottled sculpin, white sucker, mountain sucker and longnose sucker.

Fisherman Harvest and Pressure

During the period of May 1975 to April 1976, reach #1 provided approximately 33,780 fisherman days of recreation which accounted for over 50 percent of the total fishing pressure for the entire Big Hole River in this period (MDFG 1976).

During the 1977 fishing season, a 10-mile stretch of reach #1 between Melrose and Glen was studied to determine the effects of fishing pressure on the trout population. Nearly 5,900 fishermen fished this section from May 21 to November 30, 1977 (Wells and Nelson 1978). Nearly one-third of these fishermen were nonresidents. Fishing pressure was made up of nearly 4,800 bank fishermen and 1,100 float fishermen. These fishermen harvested approximately 3,400 brown trout and caught and released another 3,400. They also harvested over 1,000 rainbow trout and caught and released another 875.

Waterfowl

Reach #1 of the river is used extensively by breeding ducks and geese and as a resting stop for spring and fall migrating waterfowl. Canadian goose production is limited to islands in the river and nesting success is dependent upon flows sufficient to provide security from streambank predators. Reach #1 provides considerable waterfowl hunting opportunities.

Wildlife

White-tailed and mule deer are found along the riparian zone of the river. Furbearers include mink, beaver, muskrat and river otter. Bobcats and coyotes frequent the river banks. Ospreys nest along the river and bald eagles are observed seasonally.

Environmental Concerns

Dewatering during the irrigation season represent the most severe threat to the fishery given current water use practices in this reach. Dewatering decreases fish food production, habitat, and has been shown to cause increases in summer water temperatures in the Big Hole above those considered to be conducive to the growth and general well-being of trout (Wells and Nelson 1978).

Water may be over-allocated in this reach of the river during late summer since irrigators have the ability to almost totally dewater the lower portion of reach #1 during low water years. Any additional allocations of Big Hole River water during the low flow period would have a severe impact on the aquatic resource of reach #1.

Low flows during the late summer months are also a concern to irrigators along the lower portion of reach #1. The 1977 Montana Legislature mandated the Department of Natural Resources to study the feasibility of offstream storage sites in the Big Hole drainage. Tributary storage facilities would have the potential of providing greater flows during the lower flow period on the Big Hole River. Four potential sites have been

identified by the Department of Natural Resources.

The construction of Reichle Dam on the Big Hole River between Glen and Twin Bridges has been proposed in the past. While such a dam would provide water for downstream uses, it would inundate productive agricultural land and destroy many miles of the "Blue Ribbon" portion of the river.

Method Used For Flow Recommendations

The wetted perimeter method was used to identify the low and high levels of aquatic habitat potential (see page for detailed explanation) for the period July 16 - April 15. Six cross-sections were surveyed approximately 2½ miles downstream from Melrose. The wetted perimeter projections at various flows were generated by the IFG4 computer program.

Flow recommendations for the high water period (April 16 - July 15) were based on the dominant discharge/channel morphology concept (see page 5) and obtained from data supplied by the USGS (1978). The 1½-year frequency peak flow was used to approximate the bankfull condition.

Flow Recommendations

The relationship between wetted perimeter and flow for a composite of six cross-sections of the Big Hole River in reach #1 is shown in Figure 18. The two inflection points identified in the figure occur at flows of approximately 300 cfs and 600 cfs and correspond to the low and high level of aquatic habitat potential, respectively (see page 7).

The bankfull flow for the Big Hole River in reach #1 is about 5,630 cfs. This flow should be established for 24-hours during the first 15 days of June. During the remainder of the high water period (April 16 - July 15), the 70% exceedance flow is recommended.

Instream flows which will maintain a low and high level of aquatic habitat potential are identified in Table 15. Instream flows recommended for this reach of the Big Hole River correspond to the high level of aquatic habitat potential and amount to .68 MAF per year. Flows maintaining the low and high levels of aquatic habitat potential are compared to the mean monthly flows in Table 15. For the months of April through July, mean monthly flows exceed the recommended instream flows. Mean monthly flows for the remainder of the year are slightly less than the recommended instream flows. Any additional allocations of water during these months, particularly the low flow months of August and September, could have a severe impact on the aquatic resource.

4. REACH #2

From the site of the old Divide Dam to the mouth of Pintlar Creek. (T1S, R10W, Sec. 11 to T1S, R14W, Sec. 8)

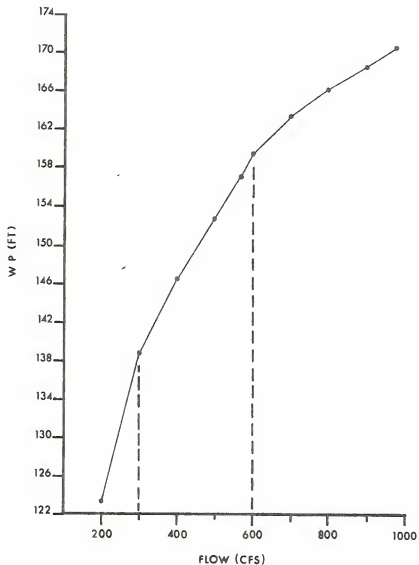


Figure 18. The relationship between wetted perimeter and flow for a composite of 6 cross-sections in reach #1 (from the mouth to the site of the old Divide Dam) of the Big Hole River.

Table 15. Instream flows representing low and high levels of aquatic habitat potential compared to mean monthly flows for reach #1 of the Big Hole River.

Time Period	Flow					
	Low 1/		High 2/		Mean	
	CFS	AF	CFS	AF	CFS	AF
January	300	18,442	600	36,884	349	21,454
February	300	16,657	600	33,314	363	20,155
March	300	18,442	600	36,884	445	27,355
April 1-15	300	8,924	600	17,847		
April 16-30	1,098	32,660	1,098	32,660	1,526	90,781
May 1-15	1,734	51,578	1,734	51,578		
May 16-31	2,626	83,318	2,626	83,318	3,449	212,020
June 1-15	3,306	102,945 ^{3/}	3,306	102,945 ^{3/}		
June 16-30	1,933	57,497	1,933	57,497	4,121	245,158
July 1-15	1,042	30,994	1,042	30,994		
July 16-31	300	9,518	600	19,037	1,347	82,804
August	300	18,442	600	36,884	482	29,630
September	300	17,847	600	35,694	377	22,428
October	300	18,442	600	36,884	507	31,167
November	300	17,847	600	35,694	508	30,221
December	300	18,442	600	36,884	398	24,466
Total		521,995		684,998		837,639

1/ Low level of aquatic habitat potential.

2/ High level of aquatic habitat potential.

3/ Includes a flow of 5,630 cfs for 24 hours.

Description

Reach #2 of the Big Hole River is approximately 39 miles long. The lower portion of this reach flows through a narrow, steep canyon from Dewey to the site of the old Divide Dam. Upstream, the river flows through meadow lands adjacent to conifer covered hillsides. The river tends to remain in one channel since it is traversing a narrower, more erosion resistant plain. Overhanging bank cover is much reduced from reach #1. Cottonwoods have nearly disappeared from the riparian zone with the increase in altitude. Willows are the most important plant providing streambank stability and overhanging cover for fish. The substrate of the river is generally of a gravel to cobble nature interspersed with finer particles in the deposition zones. The average gradient in reach #2 is somewhat greater than that of reach #1, especially downstream from Dewey.

The U.S. Geological Survey does not maintain a gaging site in reach #2. Natural flows are reduced from reach #1 but tend to follow the same patterns of high and low periods with peaks in late May or June and minimum flows in late fall or winter.

Sediment loads are generally not a problem in this reach. However, wintering cattle in the river bottom and the existence of a large feedlot operation extending into the river present localized problem areas.

Fishery

Warden creel census information from 1954-1963 indicated that rainbow trout dominated the creel during this period (Wiperman 1965). Brook trout were the next most common species creeled followed by grayling and mountain whitefish. Brown trout were evidently not caught in this reach during this period. Creel data collected in 1971 (Peterson 1973) showed hatchery rainbow trout to be the most common fish in the creel followed by wild rainbow trout, mountain whitefish, brook trout, grayling and brown trout.

Electrofishing data collected in reach #2 in 1973 (Peterson 1974) indicated that mountain whitefish was the most abundant game fish followed by wild rainbow trout, brook trout and grayling. Since 1974, the planting of hatchery rainbow trout has been heavily curtailed. Presently, hatchery rainbow are planted only in a small section of reach #2.

A 5-mile study section was established below the mouth of Bryant Creek in the fall of 1978. The following fish population estimates (Wells, unpublished data) pertain to this portion of reach #2 in fall of 1978.

Rainbow Trout

There were approximately 20 age II and older rainbow trout per 1,000 ft in this portion of reach #2. While this population

is small, it is characterized by the presence of large, trophy-size trout. Rainbows up to 8 pounds were captured during this electrofishing work. Large rainbow trout are dependent on instream cover in this reach of the river and are, therefore, seriously affected by flow reductions.

Mountain Whitefish

Whitefish are clearly the most numerous game fish in this reach. The population estimate indicated over 350 age II and older whitefish per 1,000 ft inhabited this portion of reach #2.

Other Species

Small numbers of brown trout were captured. These fish were all sexually mature and may have been upstream, migrating spawners. The importance of this reach to brown trout reproduction may be greater than previously thought. Grayling were more abundant than in reach #1, but still uncommon. Brook trout were also uncommon and cutthroat trout extremely rare. Burbot appeared to be more abundant than in reach #1. Other species present include longnose dace, mottled sculpin, white sucker, mountain sucker and longnose sucker.

Fishing Pressure

During the period from May 1975 to April 1976, reach #2 provided approximately 19,800 fisherman days of recreation (MDFG 1977). Reach #2 is also extensively used by recreational floaters during the summer months.

Waterfowl

Reach #2 is used by breeding ducks and as a resting stop for spring and fall migrating waterfowl. Waterfowl hunting is popular during the fall season.

Wildlife

White-tailed and mule deer are found along the river. Furbearers include mink, beaver and muskrat. Bobcats and coyotes frequent the river banks and ospreys and bald eagles are observed seasonally.

Environmental Concerns

Dewatering during the irrigation season represents a threat to the fishery in reach #2. Additional problems include stream-bank trampling by wintering cattle, which decreases bank stability and increases sedimentation, and the operation of a feedlot extending into the river which is the source of both organic pollution and sediment. Heavy metals pollution from the Elkhorn Mine has had severe effects on the biota of Elkhorn Creek and may well be affecting Wise River, a major tributary to the Big Hole in reach #2. Logging activities in drainages entering the Big Hole have the potential for increasing the sediment load of the river.

Method Used For Flow Recommendations

The wetted perimeter method was used in an attempt to identify the low and high levels of aquatic habitat potential (see page 7 for detailed explanation) for the period July 16 - April 15. Five cross-sections were surveyed approximately $\frac{1}{2}$ mile downstream from the mouth of Bryant Creek. The wetted perimeter projections at various flows were generated by the IFG4 computer program.

Flow recommendations for the high water period (April 16 - July 15) will be based on the dominant discharge/channel morphology concept (see page 5). This information is presently unavailable due to the lack of USGS flow records for reach #2.

Flow Recommendations

The relationship between wetted perimeter and flow for a composite of five cross-sections in reach #2 is shown in Figure 19. Inflection points are not readily discernible due to the channel characteristics. However, interpolation between reaches #1 and 3 and the authors professional judgment suggest that flows of 200 and 450 cfs correspond to the low and high levels of aquatic habitat potential, respectively.

The bankfull flow for the Big Hole River in reach #2 has not been determined due to lack of flow records. This flow should be established for a 24-hour period during the first 2 weeks of June. During the remainder of the high water period (April 16 - July 15), the 70% exceedance flow, currently undetermined, is recommended.

Instream flows which will maintain a low and high level of aquatic habitat potential are partially identified in Table 16. Instream flows recommended for reach #2 of the Big Hole River correspond to the high level of aquatic habitat potential.

5. REACH #3

From the mouth of Pintlar Creek to the headwaters of the Big Hole River.

(T1S, R14W, Sec. 8 to T7S, R16W, Sec. 36)

Description

Reach #3 of the Big Hole is approximately 34 miles long. For most of this length, the river meanders through a wide valley and in many places breaks up into more than one channel. Overhanging bank cover, comprised mostly of willows, is generally greater than that in reach #2. Willows are extremely important in this reach for providing streambank stability and overhanging cover for fish. The bottom substrate is generally finer than in the lower reaches and the gradient somewhat less steep.

The U.S. Geological Survey does not maintain a gaging station in this reach. Natural flows are less than those in reach #2. Sediment loads are generally not a problem in reach #3. However removal of streambank willows by mechanical means and

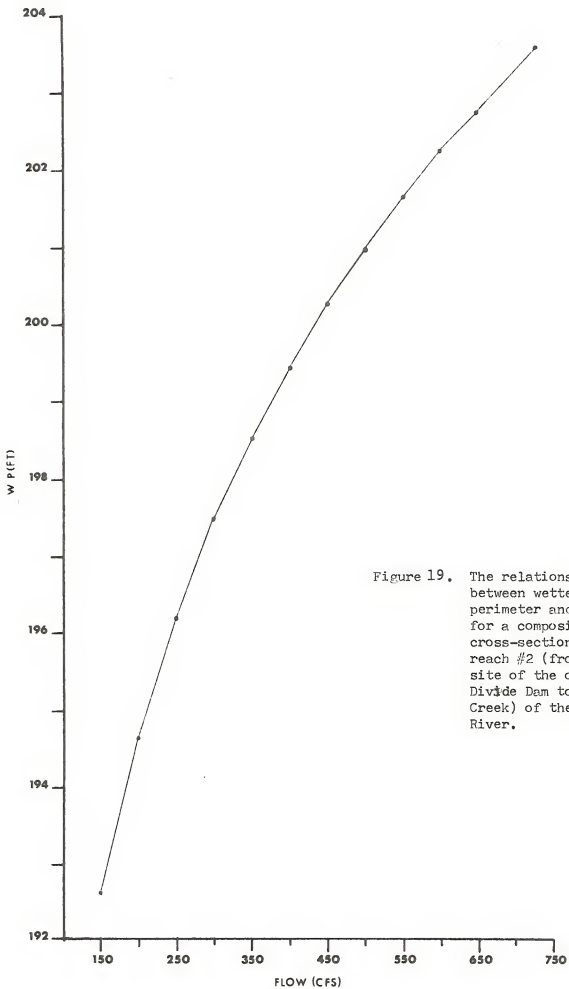


Figure 19. The relationship between wetted perimeter and flow for a composite of 5 cross-sections in reach #2 (from the site of the old Divide Dam to Pintlar Creek) of the Big Hole River.

Table 16. Instream flows representing low and high levels of aquatic habitat potential for reach #2 of the Big Hole River.

Time Period	Flow			
	Low 1/		High 2/	
	CFS	AF	CFS	AF
January	200	12,295	450	27,663
February	200	11,105	450	24,986
March	200	12,295	450	27,663
April 1-15	200	5,949	450	13,385
April 16-30	3/		3/	
May 1-15	3/		3/	
May 16-31	3/		3/	
June 1-15	3/		3/	
June 16-30	3/		3/	
July 1-15	3/		3/	
July 16-31	200	6,346	450	14,278
August	200	12,295	450	27,663
September	200	11,898	450	26,771
October	200	12,295	450	27,663
November	200	11,898	450	26,771
December	200	12,295	450	27,663

1/ Low level of aquatic habitat.

2/ High level of aquatic habitat.

3/ Flows presently unidentified.

herbicide sprays is a common practice and has the potential for increasing bank erosion and sedimentation.

Fishery

Creel census information from 1954-1963 (Wipperman 1965) indicated that brook trout dominated the creel. Rainbow trout were the next most common species in the creel followed by grayling and whitefish. Flow reductions due to irrigation withdrawals were identified as early as 1959 as limiting fish populations in reach #3. Photographs taken in August of 1959 show that the Big Hole near Wisdom was totally dewatered in one of its two channels and nearly so in the other (Heaton 1960). Reach #3 supports the highest density of grayling in the river and is, therefore, of special concern to the Montana Department of Fish and Game.

Fish Populations

A cooperative research project with the Montana Cooperative Fisheries Research Unit was begun in 1978 to determine the distribution, abundance and habitat requirements of stream-dwelling grayling in reach #3. Data will be collected through the 1979 field season.

Electrofishing data collected during the summer and fall of 1978 showed that mountain whitefish were the most numerous game fish in reach #3 followed by brook trout and grayling. Rainbow and cutthroat trout were very rare and brown trout were not found (Wells, unpublished data). Grayling numbers appeared to be greatest between Wisdom and Jackson. Other species present include burbot, longnose dace, white sucker, longnose sucker, mountain sucker and mottled sculpin.

Fishing Pressure

During the period of May 1975 to April 1976, reach #3 provided approximately 12,700 fisherman-days of recreation, representing nearly 20 percent of the fishing pressure on the entire river (MDFG 1977). Reach #3 is also used by recreational floaters during the summer months.

Waterfowl

Reach #3 is used by nesting waterfowl and as a resting stop during spring and fall migrations. Waterfowl hunting is popular during the fall season.

Wildlife

Moose and mule deer are found along the riparian zone of this reach of the river. Streambank willows provide wintering areas for moose. Furbearers present include mink, beaver and muskrat. Bobcats and coyotes frequent the river banks. Osprey and bald eagles are observed seasonally.

Environmental Concerns

Dewatering during the irrigation season represents the major threat to the fishery in reach #3 especially in the vicinity of Wisdom. Further allocations of water during low flow periods would have severe impacts on the fish populations. Extensive channel alterations have resulted in decreased habitat for aquatic life.

During the summer of 1978, aerial spraying of streambank willows with 2,4-D herbicide was extensive along the upper Big Hole and North Fork of the Big Hole River. Such practices not only put a toxic chemical into the streams, but also destroy the willow cover along the streambanks. Willows are extremely important for providing streambank stability, overhanging cover for fish and winter habitat and forage for moose. Their protection should be encouraged.

Method Used For Flow Recommendations

The wetted perimeter method was used to identify the low and high levels of aquatic habitat potential (see page 7 for detailed explanation) for the period July 16 - April 15. Five cross-sections were surveyed approximately 4 miles downstream from Jackson. The wetted perimeter projections at various flows were generated by the IFG4 computer program.

Flow recommendations during the high water period (April 16 - July 15) will be based on the dominant discharge/channel morphology concept (see page 5). This information is presently unavailable due to the lack of USGS flow records for reach #3.

Flow Recommendations

The relationship between wetted perimeter and flow for a composite of five cross-sections in reach #3 is shown in Figure 20. The two inflection points identified in the figure occur at flows of approximately 100 cfs and 250 cfs and correspond to the low and high levels of aquatic habitat potential, respectively (see page 7).

The bankfull flow for reach #3 has not been determined due to the lack of flow records. This flow should be established for a 24-hour period during the first 2 weeks of June. During the remainder of the high water period (April 16 - July 15), the 70% exceedance flow, currently undetermined, is recommended (see page 5).

Instream flows which will maintain a low and high level of aquatic habitat potential are partially identified in Table 17. Instream flows recommended for reach #3 of the Big Hole River correspond to the high level of aquatic habitat potential.

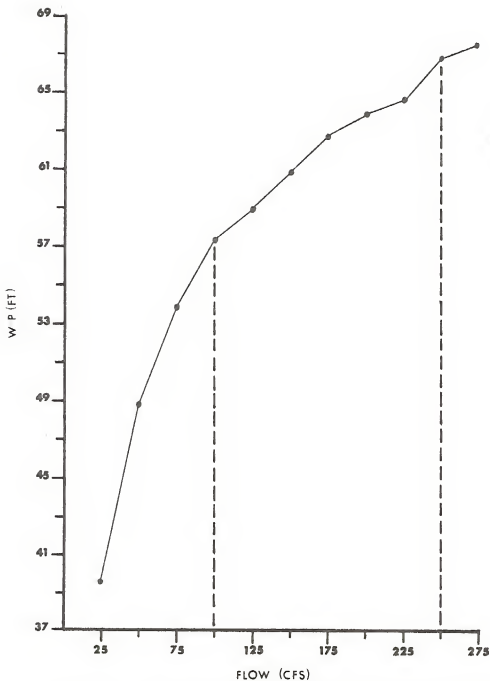


Figure 20. The relationship between wetted perimeter and flow for a composite of 5 cross-sections in reach #3 (from Pintlar Creek to the headwaters) of the Big Hole River.

Table 17. Instream flows representing low and high levels of aquatic habitat potential for reach #3 of the Big Hole River.

Time Period	Flow			
	Low 1/ CFS	AF	High 2/ CFS	AF
January	100	6,147	250	15,368
February	100	5,552	250	13,881
March	100	6,147	250	15,368
April 1-15	100	2,975	250	7,436
April 16-30	3/		3/	
May 1-15	3/		3/	
May 16-31	3/		3/	
June 1-15	3/		3/	
June 16-30	3/		3/	
July 1-15	3/		3/	
July 16-31	100	3,173	250	7,932
August	100	6,147	250	15,368
September	100	5,949	250	14,873
October	100	6,147	250	15,368
November	100	5,949	250	14,873
December	100	6,147	250	15,368

1/ Low level of aquatic habitat potential.

2/ High level of aquatic habitat potential.

3/ Flows presently unidentified.

1. STREAM

Ruby River

2. GENERAL DESCRIPTION

The Ruby River (Figure 21) arises from tributaries located in the Gravelly and Snowcrest mountains. The river flows in a northwesterly direction through a narrow valley to Ruby Reservoir. Below Ruby Reservoir the river meanders about 62 miles through an agricultural valley to its confluence with the Beaverhead River.

Ruby Reservoir, built in 1939, is used for the storage of irrigation water. The storage capacity at construction was 38,850 acre-feet. The average water yield above the reservoir is about 128,300 acre-feet. Water storage, which occurs during the winter months, results in greatly reduced flows in the river below Ruby Dam.

Cattle and elk grazing is the dominant use in the headwaters. Past overgrazing coupled with fragile soil types has accelerated erosion rates in some areas (Page 1978). Widespread sagebrush removal was accomplished by herbicide spraying during the 1960's.

Irrigated croplands are common in the valley below Ruby Dam. Along the lower river, the removal of bank vegetation has been extensive and considerable riprap occurs.

Invertebrate sampling below the dam shows a decreased biomass due to sedimentation of the substrate. Combined totals of the orders Coleoptera (aquatic beetles) and Plecoptera (stoneflies), especially susceptible to silt deposition, were never documented in greater concentrations than two individuals per square foot. However, the order Ephemeroptera (mayflies) averaged greater than 51 individuals per square foot. This was attributed to the mud burrowing forms of mayflies (Greene et al. 1971).

Trout fishing in the river below Ruby Dam is considered good. Brown trout, which occasionally reach weights of 3 pounds and greater, are the dominant trout species in this area. In 1973, estimates of the number of age I and older brown trout in study sections below the dam ranged from 81 to 255 per 1,000 ft of river. The variation was shown to be strongly associated with the quality of habitat while it was inversely related to channel and streambank alterations (Peterson 1974). Other fish present

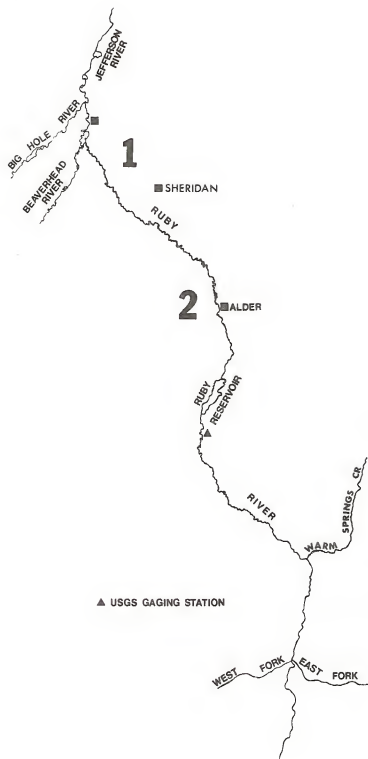


Figure 21. Map of the Ruby River.

in the lower river are brook trout, rainbow trout, mountain whitefish, white sucker, longnose sucker, mountain sucker, mottled sculpin and longnose dace.

Cutthroat and brook trout are the dominant trout species in the headwaters of the Ruby River while rainbow and brown trout are dominant in the portion of river between the mouth of Warm Springs Creek and Ruby Reservoir. The headwater area is noted for excellent elk and deer hunting.

3. REACH #1

From the mouth to the bridge west of Sheridan.
(T4S, R6W, Sec. 4 to T5S, R5W, Sec. 5)

Description

The Ruby River in reach #1 meanders through agricultural lands in the wide, open Ruby valley. The floodplain is primarily used for cattle grazing and irrigated haylands. Access to the river is with permission by private landowners. Some recreational floating occurs.

Fishery

See GENERAL DESCRIPTION

Waterfowl

Ducks and geese use the river during spring and fall migration. Nesting waterfowl include Canada geese, mallard, blue-winged teal and common merganser.

Wildlife

Although riparian vegetation in some areas has been severely reduced, this habitat is generally satisfactory for wildlife. Both white-tailed and mule deer reside in the bottomland as well as some moose. Good populations of Hungarian partridge and some ring-necked pheasants make extensive use of this vegetation. All common predators, including coyote, red fox and raccoon, maintain strong populations along the river. Furbearers include beaver, muskrat, mink and river otter.

Environmental Concerns

The most obvious concern in the lower river is excessive sedimentation. Extensive overuse of the fragile upper drainage for cattle grazing and the geologic conditions in the area have resulted in erosion problems (Page 1978). The destruction of streambank vegetation by livestock has further aggravated the stability of the channel. Bank vegetation helps to prevent the lateral migration of the river channel by stabilizing the banks. This movement threatens development within the floodplain.

Channel and bank alterations are common on the Ruby River below the dam. As of 1973, a total of 280 riverbank and 53 channel alterations were documented. They comprised 17.2 and 8.3 percent, respectively, of the 62 miles of the lower river. Extensive alteration results in the removal of riparian vegetation. This vegetation provides overhanging cover for fish, controls soil erosion and helps to stabilize the channel.

When water is stored in Ruby Reservoir during the winter months, flows below the dam are greatly reduced. A water management plan that would provide greater flows during the winter period should be encouraged. Portions of the river are also dewatered during the summer irrigation season.

During periods of extreme drawdown, the discharge from Ruby Reservoir is extremely turbid. This is attributed to bottom sediments being drawn into suspension by currents generated on the reservoir floor. If this problem continues, it could have an impact on the fishery.

Increasing water temperatures are a potential problem. The filling in of Ruby Reservoir with sediments and the removal of riverbank vegetation can lead to temperature increases. These increases could be detrimental to the existing cold water fishery in the lower river.

Method Used For Flow Recommendations

The wetted perimeter method was used to identify the flows providing the low and high levels of aquatic habitat potential (see page 7 for a detailed explanation) from July 16 through April 30. Five cross-sections were surveyed in reach #1 (T4S, R6W, Sec. 10). The wetted perimeter projections at various flows were generated using the IFG4 computer program.

Flow recommendations for the high water period (May 1 - July 15) will be based on the dominant discharge/channel morphology concept (see page 5). The information needed to derive these recommendations is presently unavailable due to the lack of USGS flow records for reach #1.

Flow Recommendations

The relationship between wetted perimeter and flow for a composite of five cross-sections in reach #1 is shown in Figure 22. The two inflection points occur at approximate flows of 75 and 125 cfs and correspond to the low and high level of aquatic habitat potential, respectively (see page 7).

The bankfull flow, presently undetermined, should be established for 24 hours during June 1-15. During the remainder of the high water period (May 1 - July 15), the 70% exceedance flows, presently undetermined, are recommended.

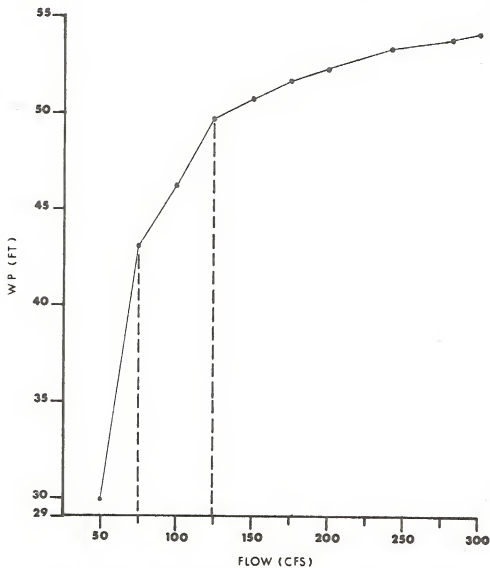


Figure 22. The relationship between wetted perimeter and flow for a composite of 5 cross-sections in reach #1 (from the mouth to Sheridan) of the Ruby River.

The instream flows that will maintain a low and high level of aquatic habitat potential are partially identified in Table 18. The instream flows recommended for reach #1 of the Ruby River correspond to the high level of aquatic habitat potential.

4. REACH #2

From the bridge west of Sheridan to Ruby Dam.
(T5S, R5W, Sec. 5 to T7S, R4W, Sec. 8)

Description

Reach #2 meanders through agricultural lands within the Ruby valley. The floodplain along the river is used for grazing and irrigated croplands. Riverbank and channel alterations are common. The dewatering of the river during the summer irrigation season is a major problem in this reach.

Fishery

See GENERAL DESCRIPTION

Waterfowl

Same as reach #1

Wildlife

Same as reach #1

Environmental Concerns

Same as reach #1

Method Used For Flow Recommendations

The wetted perimeter method was used to identify the flows providing a low and high level of aquatic habitat potential (see page 7 for a detailed explanation) from July 16 through April 30. Five cross-sections were surveyed in reach #2 (T6S, R4W, Sec. 8). The wetted perimeter projections at various flows were generated using the IFG4 computer program.

Flow recommendations for the high water period (May 1 - July 15) are based on the dominant discharge/channel morphology concept (see page 5) and obtained from data supplied by the USGS (1975 and 1978). The 1 $\frac{1}{2}$ -year frequency peak flow was used to approximate the bankfull flow.

Flow Recommendations

The relationship between wetted perimeter and flow for a composite of five cross-sections in reach #2 is shown in Figure 23. The two inflection points occur at approximate flows of 50 and 70 cfs and correspond to the low and high level of aquatic habitat potential, respectively (see page 7).

Table 18. Instream flows representing low and high levels of aquatic habitat potential for reach #1 of the Ruby River.

Time Period	Flow			
	Low <u>1/</u>		High <u>2/</u>	
	CFS	AF	CFS	AF
January	75	4,610	125	7,684
February	75	4,164	125	6,941
March	75	4,610	125	7,684
April	75	4,462	125	7,436
May	3/		3/	
June	3/		3/	
July 1-15	3/		3/	
July 16-31	75	2,380	125	3,966
August	75	4,610	125	7,684
September	75	4,462	125	7,436
October	75	4,610	125	7,684
November	75	4,462	125	7,436
December	75	4,610	125	7,684

1/ Low level of aquatic habitat potential.

2/ High level of aquatic habitat potential.

3/ Flows presently unidentified.

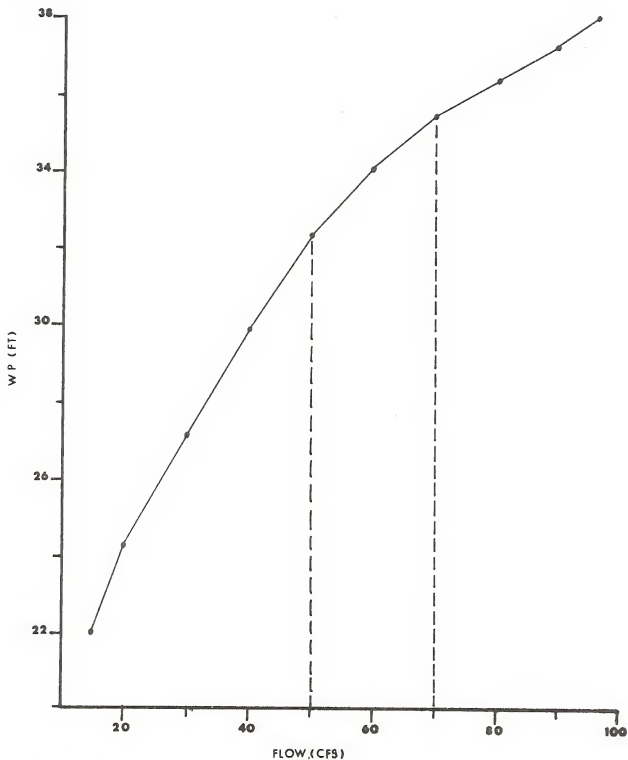


Figure 23. The relationship between wetted perimeter and flow for a composite of 5 cross-sections in reach #2 (from Sheridan to Ruby Dam) of the Ruby River.

The bankfull flow, estimated at 792 cfs, should be established for 24 hours during June 1-15. For the remainder of the high water period (May 1 - July 15), the 70% exceedance flows are recommended. The bankfull and 70% exceedance flows were computed from data collected at the USGS gage above Ruby Reservoir. The flows at this gage are not regulated by Ruby Dam and, therefore, reflect the natural high water period.

The instream flow that will maintain a low and high level of aquatic habitat potential are identified in Table 19. The instream flows recommended for reach #2 of the Ruby River correspond to the high level of aquatic habitat potential and amount to 84,004 acre-feet per year. Since the mean monthly flows in Table 19 were derived for the USGS gage above Ruby Reservoir and, therefore, do not reflect regulation by Ruby Dam, a comparison of the recommended flows and the mean monthly flows for reach #2 is not possible. The mean monthly flows in Table 19 reflect the natural flow pattern of reach #2 before Ruby Dam was constructed.

Table 19. Instream flows representing low and high levels of aquatic habitat potential compared to mean monthly flows for reach #2 of the Ruby River.

Time Period	Flow					
	Low 1/		High 2/		Mean	
	CFS	AF	CFS	AF	CFS	AF
January	50	3,074	70	4,303	102	6,270
February	50	2,776	70	3,887	101	5,608
March	50	3,074	70	4,303	109	6,701
April	50	2,975	70	4,164	161	9,578
May 1-15	213	6,336	213	6,336		
May 16-31	380	12,057	380	12,057	405	24,897
June 1-15	400	12,676 ^{3/}	400	12,676		
June 16-30	260	7,734	260	7,734	468	27,841
July 1-15	171	5,086	171	5,086		
July 16-31	50	1,586	70	2,221	190	11,680
August	50	3,074	70	4,303	118	7,254
September	50	2,975	70	4,164	117	6,960
October	50	3,074	70	4,303	119	7,315
November	50	2,975	70	4,164	123	7,317
December	50	3,074	70	4,303	112	6,885
Total		72,546		84,004		128,306

1/ Low level of aquatic habitat potential

2/ High level of aquatic habitat potential

3/ Includes a flow of 792 cfs for 24 hours.

1. RIVER

Red Rock River

2. GENERAL DESCRIPTION

The Red Rock River (Figure 24) arises from Lower Red Rock Lake in the Centennial Valley of southwestern Montana. The river flows westward for approximately 17 miles before entering Lima Reservoir. The river leaves the reservoir and flows approximately 34 miles in a northwesterly direction before entering Clark Canyon Reservoir.

The river has an average width of approximately 45 feet. The most common substrate type is gravel and cobble. Sediment deposition is a problem in many portions of the river. Major tributaries entering the river include Sage Creek, Junction Creek, Big Sheep Creek and Little Sheep Creek.

Lima Reservoir, built in 1902, serves as a storage reservoir for downstream irrigators and markedly alters the natural flow regime of the Red Rock River.

3. REACH #1

From Clark Canyon Reservoir to Lima Dam.
(T10S, R10W, Sec. 29 to T13S, R6W, Sec. 32)

Description

See GENERAL DESCRIPTION

Fishery

Historically, the river supported game fish populations of cutthroat trout, arctic grayling and mountain whitefish. Rainbow, brown and brook trout have been introduced to the drainage. Today, cutthroat trout are found only in the river upstream from Lima Reservoir and grayling may be gone from the river. From Lima Reservoir to the mouth of the river, the Red Rock provides a quality trout fishery for brown and rainbow trout and mountain whitefish. This section of the river provided over 1,800 fisherman days of recreation from May 1975 to April 1976 (MDFG 1976). Little public access is available.

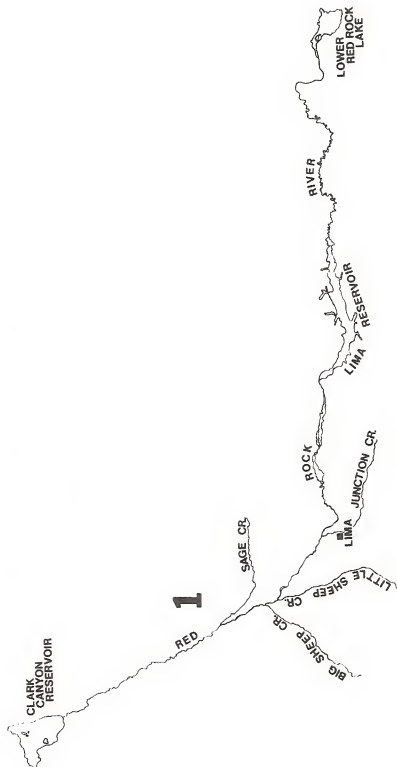


Figure 24. Map of the Red Rock River.

Electrofishing has indicated a population of about 200 trout per 1,000 ft of river (Gaffney 1962 and Peterson 1975). Brown trout are the dominant trout species in the lower river followed by rainbow trout. Other species present include mountain whitefish, brook trout, burbot (ling), white sucker, longnose sucker, mountain sucker, longnose dace and mottled sculpin.

In addition to resident fish populations, the lower portion of the river provides spawning and nursery areas for brown and rainbow trout residing in Clark Canyon Reservoir. Brown trout migrate up the river in the fall and rainbows in the spring. During these runs, trophy size trout in the 5-pound class are taken by fishermen.

Waterfowl

The Red Rock River is used extensively by waterfowl and provides considerable recreational opportunities for waterfowl hunters.

Wildlife

White-tailed and mule deer are found along the riparian zone of the Red Rock. Furbearers present include mink, beaver and muskrat. Ospreys and bald eagles are observed seasonally along the river.

Environmental Concerns

Aquatic habitat conditions are fairly good throughout the river. However, sedimentation due to poor land use practices, including the denuding of streambanks and overgrazing, is a problem. Additional problems include extremely low winter releases from Lima Reservoir which have resulted in fish kills below the dam.

Method Used For Flow Recommendations

The wetted perimeter method was used in an attempt to identify the low and high levels of aquatic habitat potential (see page 7 for detailed explanation) for the July 1 through April 15 period. Five cross-sections were surveyed approximately 4 miles upstream from Clark Canyon Reservoir. Due to a relatively constant flow from late July through the fall months, only one set of cross-sectional measurements was obtained.

The relationship between wetted perimeter and flow for a composite of five cross-sections was generated using the WSP computer program. However, field measurements did not include the elevations above the water surface, information needed to generate meaningful data. As a result, wetted perimeters could not be generated for flows greater than 219 cfs. The flow recommendations in this report were derived using professional judgment based on an evaluation of photographs of the Red Rock River at various flows.

Future flow recommendations for the high water period (April 16 - June 30) will be based on the dominant discharge/channel morphology concept (see page 5). The information needed to derive these flow recommendations is presently unavailable due to the lack of long-term USGS gage records for this reach of the Red Rock River.

Flow Recommendations

The flows providing a low and high level of aquatic habitat potential, based on professional judgment, are 125 and 225 cfs, respectively.

The bankfull discharge for this reach of the river is currently unknown. However, this flow should be established for a 24-hour period during the first 2 weeks of June. During the remainder of the high water period (April 16 - June 30), the 70% exceedance flow, currently unknown, is recommended (see page 5 for explanation).

Instream flows which will maintain a low and high level of aquatic habitat potential are partially identified in Table 20. Instream flows recommended for reach #1 of the Red Rock River correspond to the high level of aquatic habitat potential.

Table 20. Instream flows representing low and high levels of aquatic habitat potential for reach #1 of the Red Rock River.

Time Period	Flow			
	Low 1/		High 2/	
	CFS	AF	CFS	AF
January	125	7,684	225	13,831
February	125	6,941	225	12,493
March	125	7,684	225	13,831
April 1-15	125	3,718	225	6,693
April 16-30	3/		3/	
May 1-15	3/		3/	
May 16-31	3/		3/	
June 1-15	3/		3/	
June 16-30	3/		3/	
July	125	7,684	225	13,831
August	125	7,684	225	13,831
September	125	7,436	225	13,385
October	125	7,684	225	13,831
November	125	7,436	225	13,385
December	125	7,684	225	13,831

1/ Low level of aquatic habitat potential.

2/ High level of aquatic habitat potential.

3/ Flows presently unidentified.

1. RIVER

Jefferson River

2. GENERAL DESCRIPTION

The Jefferson River is 77 miles long from its origin at the junction of the Big Hole and Beaverhead rivers to Three Forks, Montana, where it joins the Madison and Gallatin rivers to form the Missouri River (Figure 25). The average width of the river is about 197 ft. The gradient averages 7.3 ft per mile and sinuosity is 1.60. The bottom substrate is primarily gravel-cobble. Heavy depositions of silt occur at some main river sites and in many side channels.

Throughout its length, the Jefferson River is extensively used as a source of irrigation water. In below average water years, portions of the river are severely dewatered. Two irrigation storage reservoirs (Ruby and Clark Canyon Reservoirs) on major upstream tributaries affect the flow pattern of the river.

The mean flow for a 25-year period of record at the USGS gage near Silver Star was 1,714 cfs. Flows ranged from 50 to 20,300 cfs. The high water period occurs from April through July with peak flows occurring in June.

The mean flow for a 31-year period of record for the USGS gage near Sappington on the lower river was 2,121 cfs. Flows ranged from 134 to 21,000 cfs.

In addition to fishing, the Jefferson River provides many other recreational opportunities. Waterfowl hunting, trapping, floating, sight-seeing and asparagus picking are popular on the river and its adjacent bottomland. Public access is limited to sites near Whitehall and Cardwell. However, private land-owners are quite receptive to allowing access to the recreationist.

Between May 1975 and April 1976, fishing pressure in fisherman days for the Jefferson River was estimated at 26,374 (MDFG 1976). Of the 10 major rivers in the upper Missouri drainage of southwest Montana, the Jefferson ranks fourth behind the Madison, Big Hole and West Gallatin rivers in total fishing pressure.

3. REACH #1

From the Missouri River to the confluence of the Boulder River. (T2N, R2E, Sec. 17 to T1N, R3W, Sec. 11)

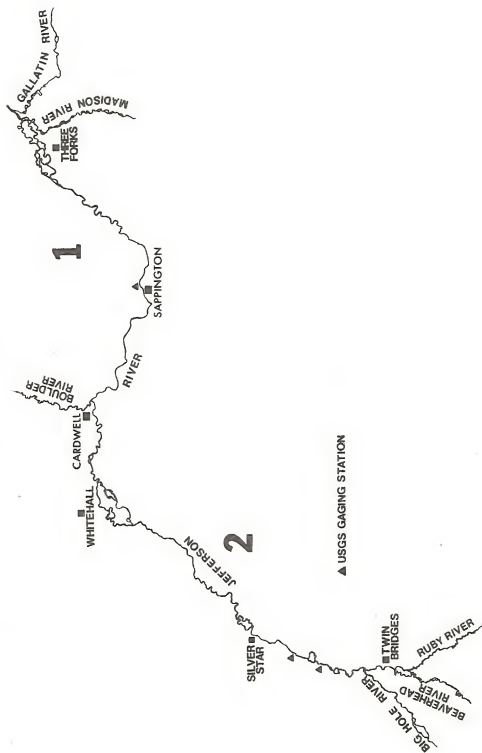


Figure 25. Map of the Jefferson River.

Description

The Jefferson River in reach #1 is primarily confined to a single channel except near Three Forks where the river braids forming many islands and side channels. Main tributaries in reach #1 are Willow Creek, the south Boulder River and the Boulder River. All three are severely dewatered in most years and only the Boulder contributes a significant volume of flow during the high water period.

Fishery

Reach #1 of the Jefferson River supports good salmonid populations. Estimates of brown trout, the dominant trout species, and mountain whitefish were made on a side channel of the Jefferson River at Three Forks in spring 1978 (Wells and Nelson 1978). The side channel supported 423 brown trout and 4,533 mountain whitefish per mile of river. Other species found in reach #1 and their relative abundance are:

Rainbow trout	uncommon
Mountain sucker	uncommon
Longnose sucker	abundant
White sucker	abundant
Longnose dace	uncommon
Golden shiner	rare
Flathead chub	uncommon
Carp	common
Mottled sculpin	uncommon
Stonecat	rare
Yellow perch	rare
Black crappie	rare
Largemouth bass	rare

The magnitude of the fish populations in the main channel of the Jefferson River has not been determined. Preliminary sampling has indicated the presence of trophy-size trout greater than 3 pounds in weight.

Waterfowl

Waterfowl commonly nest in the Jefferson River valley. Substantial numbers of Canada geese nest between Cardwell and Waterloo. Duck production is excellent in the many sloughs along the river. Various waterfowl, including swans, visit the area during migration. Goldeneyes and mergansers are common winter residents.

Wildlife

The riparian habitat along the Jefferson River is extensive due to the many river meanders. This habitat supports excellent populations of furbearers including beaver, muskrat, mink and river otter. Both mule deer and white-tailed deer inhabit the river bottom. Bald eagles winter along the river. A great blue heron rookery is located near Caldwell.

Environmental Concerns

The aquatic habitat is relatively good throughout reach #1, but major problems do exist. The dewatering of the river due to irrigation withdrawals during the summer growing season is a major concern. Flows as low as 134 cfs have been recorded at the USGS gage at Sappington. This extreme reflects irrigation withdrawals during a low water year. In other rivers where fish population data exist, flow reductions of this magnitude have severely reduced the populations of trout. Another problem directly related to dewatering is the increase in water temperatures. Documentation of this problem is intermittent, but some records are available for 1963, and 1971 through 1974. Daily maximum temperatures during these years ranged from 74 to 79 F. Temperatures about 70 F are generally considered undesirable for trout.

The natural tendency of the river to migrate within its floodplain affects agricultural lands, pastures, homesites, bridges and irrigation diversions. Various methods to stabilize the channel and protect the floodplain development have been tried. Many of these projects, especially those which block high water channels, have aggravated the instability problem. Many projects have also increased sedimentation and removed overhanging bank vegetation, both detrimental to the aquatic resource. A survey in 1973 showed about 10% of the river had "man caused" channel alterations (Peterson 1973).

Methods Used For Flow Recommendations

The wetted perimeter method was used to identify the low and high levels of aquatic habitat potential (see page 7 for detailed explanation) from July 16 through March 31. Five cross-sections were surveyed in the canyon area below Cardwell (T2S, R6W, Sec. 12). The wetted perimeter projections at various flows were generated by the IFG4 computer program.

Flow recommendations for the high water period (April 1 to July 15) are based on the dominant discharge/channel morphology USGS (1978). The 1½-year frequency peak flow was used to approximate the bankfull condition.

Flow Recommendations

The relationship between wetted perimeter and flow for a composite of five cross-sections in reach #1 is shown in Figure 26. The two inflection points occur at approximate flows of 600 and 1,000 cfs and correspond to the low and high level of aquatic habitat potential, respectively (see page 7).

The bankfull flow, estimated at 7,330 cfs, should be established for 24 hours during June. For the remainder of the high water period (April 1 - July 15), the 70% exceedance flows are recommended (see page 5). The bankfull and 70% exceedance flows were computed from data collected at the USGS gage at Sappington.

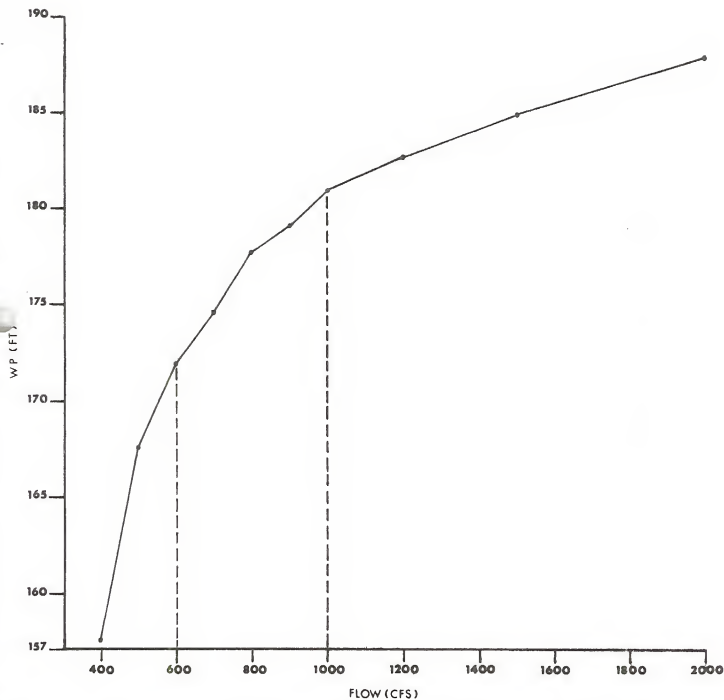


Figure 26. The relationship between wetted perimeter and flow for a composite of 5 cross-sections in reach #1 (from the mouth to the Boulder River) of the Jefferson River.

The instream flows that will maintain a low and high level of aquatic habitat potential are identified in Table 21. The instream flows recommended for reach #1 of the Jefferson River correspond to the high level of aquatic habitat potential and amount to 1.10 MAF per year. For all months, except August and September, the mean monthly flows exceed the recommended flows (Table 21). The mean monthly flows for August and September reflect the dewatering of the Jefferson River during the summer irrigation season. Any additional depletions during these two months could severely impact the aquatic resource.

4. REACH #2

From the confluence of the Boulder River to the confluence of the Big Hole and Beaverhead rivers.
(T1N, R3W, Sec. 11 to T3S, R6W, Sec. 21)

Description

Much of the Jefferson River in reach #2 is braided and meanders widely. Numerous tributaries flow into the Jefferson from the west slope of the Tobacco Root Mountains. Virtually all of the tributaries are either intermittent or entirely diverted before reaching the river.

Fishery

Reach #2 provides a good brown trout fishery. Brown trout in the 5 pound class are taken annually with 1½-2 pound trout common.

Estimates of brown trout and mountain whitefish were made on a side channel of the Jefferson River near Whitehall in spring 1978 (Wells and Nelson 1978). The side channel supported 729 brown trout and 6,566 mountain whitefish per mile of river. Other species found in reach #2 and their relative abundance are:

Rainbow trout	uncommon
Brook trout	rare
Mountain sucker	uncommon
Longnose sucker	abundant
White sucker	abundant
Longnose dace	uncommon
Carp	uncommon

The magnitude of the trout population in the main channel of the Jefferson River is presently undetermined.

Waterfowl

Same as reach #1.

Wildlife

Same as reach #1.

Table 21. Instream flows representing low and high levels of aquatic habitat potential compared to mean monthly flows for reach #1 of the Jefferson River.

Time Period	Flow					
	Low 1/		High 2/		Mean	
	CFS	AF	CFS	AF	CFS	AF
January	600	36,884	1,000	61,473	1,186	72,907
February	600	34,504	1,000	55,524	1,295	71,904
March	600	36,884	1,000	61,473	1,444	88,767
April	1,870	111,246	1,870	111,246	2,637	156,875
May	2,790	171,510	2,790	171,510	4,659	286,403
June 1-15	4,827	148,542 ^{3/}	4,827	148,542 ^{3/}	5,739	341,413
June 16-30	3,281	97,593	3,281	97,593		
July 1-15	1,864	55,445	1,864	55,445	2,032	124,913
July 16-31	600	19,037	1,000	31,728		
August	600	36,884	1,000	61,473	745	45,797
September	600	35,694	1,000	59,490	969	57,646
October	600	36,884	1,000	61,473	1,388	85,325
November	600	35,694	1,000	59,490	1,658	98,634
December	600	36,884	1,000	61,473	1,428	87,783
Total		893,685		1,097,933		1,518,367

1/ Low level of aquatic habitat potential.

2/ High level of aquatic habitat potential.

3/ Includes a flow of 7,330 cfs for 24 hours.

Environmental Concerns

Dewatering, the elevated water temperatures associated with dewatering, and the increased sedimentation and loss of fish habitat resulting from river bank and channel alterations are also problems in reach #2.

Method Used For Flow Recommendations

The wetted perimeter method was used to identify the low and high levels of aquatic habitat potential (see page 7 for detailed explanation) from July 16 through March 31. Six cross-sections were surveyed just upstream from Silver Star (T1N, R2W, Sec. 22). The wetted perimeter projections at various flows were generated by the IFG4 computer program (see page 7).

Flow recommendations for the high water period (April 1 - July 15) will be based on the dominant discharge/channel morphology concept (see page 5). The 1½-year frequency peak flow was used to approximate the bankfull condition.

Flow Recommendations

The relationship between wetted perimeter and flow for a composite of six cross-sections in reach #2 is shown in Figure 27. The two inflection points occur at approximate flows of 600 and 1,200 cfs and correspond to the low and high level of aquatic habitat potential, respectively (see page 7).

The bankfull flow, estimated at 5,777 cfs, should be established for 24 hours during June 1 - 15. For the remainder of the high water period (April 1 - July 15), the 70% exceedance flows, presently unidentified, are recommended (see page 5). This data will be available when flow records for the USGS gage at Silver Star are summarized.

The instream flows that will maintain a low and high level of aquatic habitat potential are partially identified in Table 22. The instream flows recommended for reach #2 of the Jefferson River correspond to the high level of aquatic habitat potential. From August through March, the recommended flows are about equal to or greater than the mean monthly flows. The mean monthly flows for August and September reflect the dewatering of the Jefferson River during the summer irrigation season. Any further depletions during the August through March period could severely impact the aquatic resource.

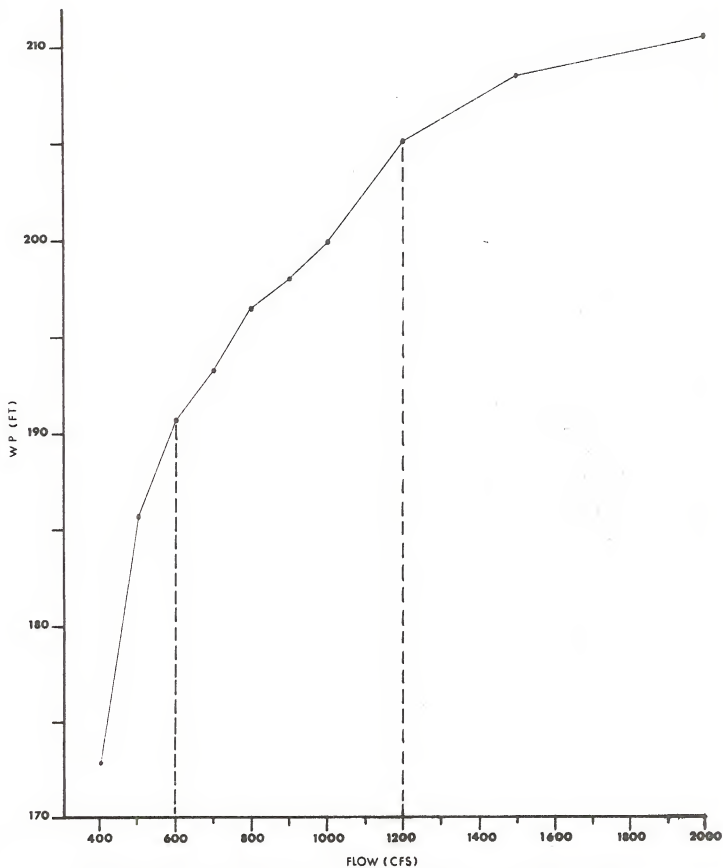


Figure 27. The relationship between wetted perimeter and flow for a composite of 5 cross-sections in reach #2 (from the Boulder River to the origin) of the Jefferson River.

Table 22. Instream flows representing low and high levels of aquatic habitat potential compared to mean monthly flows for reach #2 of the Jefferson River.

Time Period	Flow					
	Low <u>1/</u>		High <u>2/</u>		Mean	
	CFS	AF	CFS	AF	CFS	AF
January	600	36,884	1,200	73,768	958	58,891
February	600	34,504	1,200	66,629	942	54,172
March	600	36,884	1,200	73,768	1,174	72,169
April	<u>3/</u>		<u>3/</u>		2,245	133,555
May	<u>3/</u>		<u>3/</u>		3,898	239,622
June	<u>3/</u>		<u>3/</u>		4,865	289,419
July 1-15	<u>3/</u>		<u>3/</u>			
July 16-31	600	19,037	1,200	38,074	1,628	100,078
August	600	36,884	1,200	73,768	652	40,080
September	600	35,694	1,200	71,388	800	47,592
October	600	36,884	1,200	73,768	1,037	63,748
November	600	35,694	1,200	71,388	1,288	76,623
December	600	36,884	1,200	73,768	1,124	69,096
Total						1,245,045

1/ Low level of aquatic habitat potential.

2/ High level of aquatic habitat potential.

3/ Flows presently unidentified.

1. RIVER

Boulder River

2. GENERAL DESCRIPTION

The Boulder River originates on the Continental Divide at an elevation of about 7,300 ft. It flows in a southeasterly direction for 69 miles to its junction with the Jefferson River (Figure 28). The drainage basin is 762 square miles. The river between Boulder and Basin flows in a narrow canyon. Below Boulder, the river meanders through the wide, open Boulder valley. The bottom substrate in the canyon is comprised mainly of boulders, cobble and gravel. In the valley, the substrate is comprised mainly of gravel, sand and silt.

Flow in the river is presently unaltered by impoundment. However, a water project is planned for the drainage. It will divert Boulder River water into a storage reservoir on the Little Boulder River as well as store flows from the Little Boulder. Preliminary approval has been granted, but construction has not begun.

Summer flows in the lower river are often severely depleted due to irrigation diversions. Flow in the lower river is supplemented by a large spring (Big Spring).

The mean flow for a 41-year period of record at the USGS gage near Boulder was 121 cfs. Flows ranged from 0 to 3,490 cfs. The high water period occurs from April through June with peak flows occurring in May.

3. REACH #1

From the confluence with the Jefferson River to Big Spring. (T1N, R3W, Sec. 11 to T2N, R3W, Sec. 7)

Description

See GENERAL DESCRIPTION

Fishery

Portions of the Boulder River support a poor to excellent trout fishery. The dominant trout species are brook trout in the upper basin, rainbow trout in the canyon area and brown trout

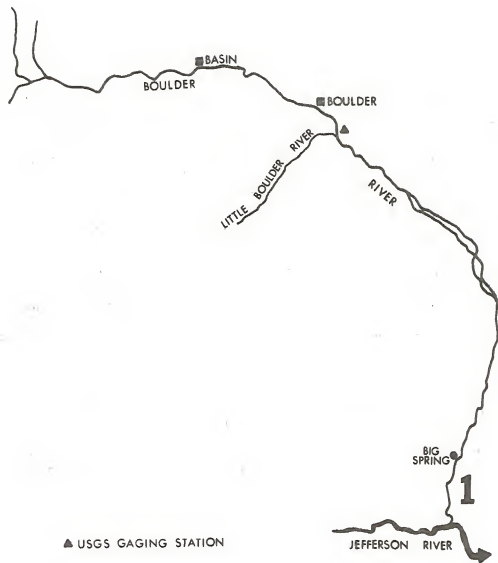


Figure 28. Map of the Boulder River.

in the valley portion below Boulder.

Between 1974 and 1976, population estimates were made in nine sections of the river (Vincent 1975 and Nelson 1976). Estimated numbers of trout per 1,000 ft of river were 403 in the upper basin, 35 to 215 in the canyon above Boulder, and 39 to 242 in the valley below Boulder. Estimated biomass of trout per 1,000 ft were 56.7 pounds in the upper basin, 6.2 to 27.4 pounds in the canyon and 15.2 to 70.2 pounds in the valley. The wide variation in numbers and biomass of trout reflects complex environmental problems which will be discussed later. Of the sections sampled, the upper most and lower most (below Big Spring) supported the highest populations of trout. The partial recovery of the trout population in the lower river probably reflects the supplemental flow (about 30 cfs) provided by Big Spring.

Resident trout in the Boulder River rarely exceed 18 inches in length with the majority less than 11 inches. Other fish present include mountain whitefish, white sucker, longnose sucker, longnose dace and mottled sculpin.

The lower 2 miles of the Boulder River are heavily used by spawning brown trout from the Jefferson and Missouri rivers. On October 28, 1977, 216 brown trout, averaging 15.3 inches in length and ranging up to 23.3 inches, were captured by electrofishing in the Boulder River near its mouth. Tag return data indicated these fish were primarily residents of the lower Jefferson and the upper Missouri rivers. A spawning concentration of this magnitude emphasizes the importance of this tributary to the fishery of the area.

Waterfowl

Waterfowl use the river during spring and fall migrations. Nesting waterfowl include mallard, blue-winged teal, and common merganser. Former river channel areas presently claimed by willow, alder, and cattail serve as habitat for this population. Canada geese have been observed in the lower Boulder during the nesting season.

Wildlife

The riparian vegetation is intermittent and usually less than 100 ft in width. Much of the remaining bottomland is used for hay production. This combination of habitats supports sharp-tailed grouse, ring-necked pheasant, sage grouse and Hungarian partridge. White-tailed deer, mule deer and American pronghorn utilize this area on a limited basis. Golden eagles are also residents in the drainage. Furbearers include beaver, muskrat, mink and river otter.

Environmental Concerns

The aquatic habitat within much of the Boulder River is in relatively poor condition. The total dewatering of portions of the river during the summer irrigation season is a common occurrence. The upper river drainage was extensively mined for metallic minerals during the late 1800's and early 1900's.

The impact of this activity on the aquatic community was first documented by Elser and Marcoux (1970). Later work found high levels of copper, lead, zinc and cadmium in the bottom substrate and floodplain of the river. Invertebrate sampling done in conjunction with the metals sampling showed fewer mayfly species and lower numbers at sites having high metal concentrations (Vincent 1975).

Research done in 1975 and 1976 concluded that these highly toxic metals were depressing the total numbers, total weight, and number of species of invertebrates in much of the river (Gardner 1976). Similar conclusions concerning the effects of metals on trout populations were also made (Nelson 1976).

In addition to dewatering and metals pollution, other problems occur. In the valley, sedimentation is excessive and extensive destruction of streambank vegetation has occurred. Sedimentation is extremely heavy below Cold Spring. A soil conservation plan is needed to control the sediment problem.

Method Used For Flow Recommendations

The wetted perimeter method was used to identify the low and high levels of aquatic habitat potential (see page 7 for detailed explanation) from June 16 to March 31. Five cross-sections were surveyed about 8 miles upstream from the mouth of the river. The wetted perimeter projections at various flows were generated by the IFG4 computer program.

Future flow recommendations for the high water period will be based on the dominant discharge/channel morphology concept (see page 5). The information needed to derive these flows is presently unavailable due to the lack of USGS records for reach #1.

Flow Recommendations

The relationship between wetted perimeter and flow for a composite of five cross-sections in reach #1 is shown in Figure 29. The two inflection points occur at approximate flows of 60 and 100 cfs and correspond to the low and high level of aquatic habitat potential, respectively.

The bankfull flow, presently undetermined, should be established for 24 hours during May 1 - 15. For the remainder of the high water period (April 1 - June 15), the 70% exceedance flows, presently undetermined, are recommended.

The instream flows that will maintain low and high levels of aquatic habitat potential are partially identified in Table 23. The instream flow recommended for reach #1 of the Boulder River correspond to the high level of aquatic habitat potential.

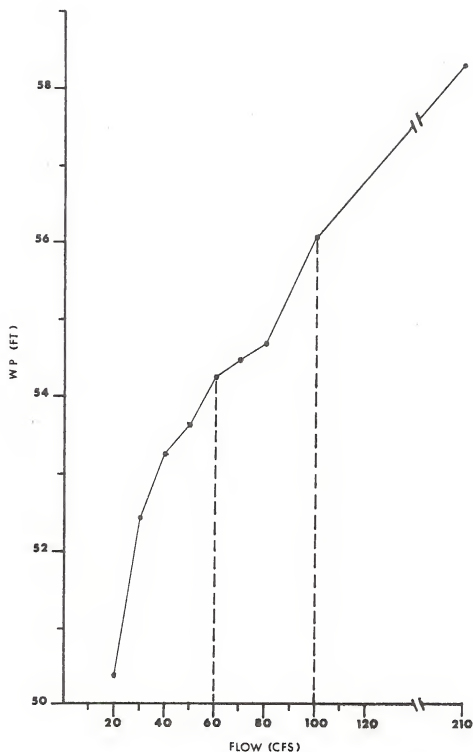


Figure 29. The relationship between wetted perimeter and flow for a composite of 5 cross-sections in reach #1 (from the mouth to Big Spring) of the Boulder River.

Table 23. Instream flows representing low and high levels of aquatic habitat potential for reach #1 of the Boulder River.

Time Period	Flow			
	Low <u>1/</u>		High <u>2/</u>	
	CFS	AF	CFS	AF
January	60	3,688	100	6,147
February	60	3,331	100	5,552
March	60	3,688	100	6,147
April	<u>3/</u>		<u>3/</u>	
May	<u>3/</u>		<u>3/</u>	
June 1-15	<u>3/</u>		<u>3/</u>	
June 16-30	60	1,785	100	2,975
July	60	3,688	100	6,147
August	60	3,688	100	6,147
September	60	3,569	100	5,949
October	60	3,688	100	6,147
November	60	3,569	100	5,949
December	60	3,688	100	6,147

1/ Low level of aquatic habitat potential.

2/ High level of aquatic habitat potential.

3/ Flows presently unidentified.

1. SPRING CREEK

Ben Hart Creek

2. GENERAL DESCRIPTION

Ben Hart Creek (Figure 30) is located in the Gallatin valley north of Belgrade, Montana. It flows 3.0 miles in a northerly direction before entering the East Gallatin River. Flows are relatively constant due to its spring creek nature. No irrigation diversions occur on the creek. The gradient is 14.2 ft per mile.

Land adjacent to Ben Hart Creek is primarily used for cattle grazing and hay and wheat production. The streambanks are either vegetated with willow and alder or open due to intense cattle use. Overuse by cattle has caused extensive bank erosion. The bottom type is primarily cobble-gravel. Much of the bottom is covered by a layer of sediment.

3. REACH #1

From the mouth to the headwaters.
(T1N, R4E, Sec. 11 to T1N, R4E, Sec. 24)

Description

See GENERAL DESCRIPTION

Fishery

Brown trout, rainbow trout and an occasional brook trout and mountain whitefish comprise the sport fishery in Ben Hart Creek. Brown and rainbow trout occasionally reach weights of 4 to 5 pounds, but few exceed 2 pounds.

Access is provided by permission of the landowner. From May 1975 through April 1976, the creek provided an estimated 1,329 fisherman days of recreation (MDFG 1976).

Waterfowl

Heavy waterfowl use occurs during the fall and winter months. Blue-winged teal and mallards commonly nest along the creek.

Wildlife

Big game animals found along the creek are mule deer and

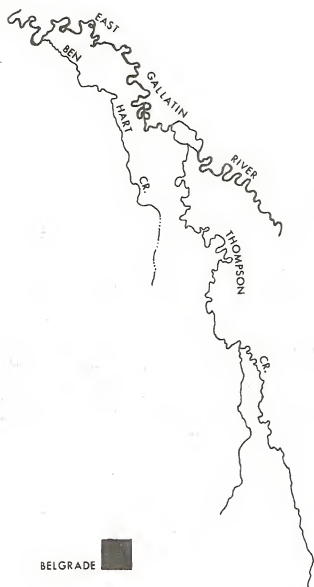


Figure 30. Map of Ben Hart and Thompson Creeks.

white-tailed deer. Upland game birds include Hungarian partridge and ring-necked pheasant. The greater sandhill crane is commonly observed in the summer.

Environmental Concerns

The destruction of streambank vegetation due to overuse by cattle is a major concern along the creek. Eroding, unstable banks have resulted in the widening and the filling in of the channel with sediments. The amount of trout habitat is declining at a rapid rate.

Method Used For Flow Recommendations

Spring creeks are a highly productive recreational resource that can provide outstanding habitat for trout and waterfowl. Due to the unique features of the spring creek environment and their high recreational value, all efforts should be made to prevent the further degradation of the few remaining spring creeks in Montana. Any water withdrawals would only accelerate the demise of this already declining aquatic resource.

Flow Recommendations

It is recommended that all flow in spring creeks be maintained for instream uses.

1. STREAM

O'Dell Creek

2. GENERAL DESCRIPTION

O'Dell Creek (Figure 31) is located in the upper Madison River valley. It flows in a northerly direction parallel to the Madison River for about 10.3 miles before entering the river 1 mile north of Ennis. The entire length of the creek is within the Madison River floodplain and is subject to overflow from the river during extreme high water periods and extreme cold periods in December through February when ice jams cause flooding. Except for these periods, there is little variation in annual flows. An instantaneous flow of 109 cfs was measured on June 11, 1969 near the mouth of the creek. The gradient is 19.4 ft per mile.

The vegetation on the land adjacent to the creek consists of cottonwood, willow, alder, grasses and assorted small shrubs. The immediate streambank is of three types: heavily covered with willows and alder, open grassland, and open and eroding due to heavy livestock use. The stream has a pool-riffle sequence with extensive areas of overhanging brush and undercut banks. The bottom type is cobble-gravel with some fine silts. The adjacent land use is primarily for cattle grazing. Annual flooding prevents homesite and cropland development. There is one small irrigation diversion about 50 ft below the Highway 289 bridge near Ennis.

3. REACH #1

From the mouth to the headwaters
(T5S, R1W, Sec. 27 to T7S, R1W, Sec. 9)

Description

See GENERAL DESCRIPTION

Fishery

Brown trout, rainbow trout, mountain whitefish and an occasional brook trout comprise the sport fishery in O'Dell Creek (Vincent 1968). Brown trout, the dominant game fish, reach weights to 5 pounds, but few exceed 3 pounds. Trout population estimates were made from 1967 through 1973. Population estimates in 1973 showed 637 2-year and older brown trout per mile of creek and 341 pounds per mile (Vincent 1976).

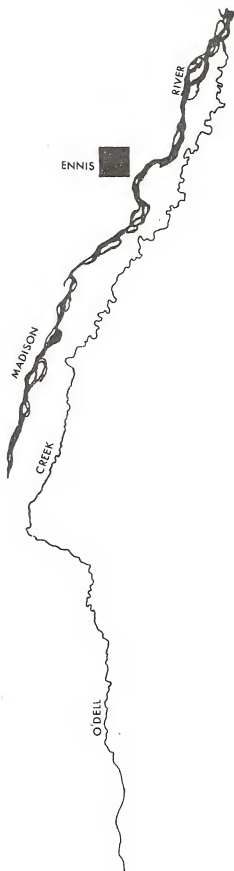


Figure 31. Map of O'Dell Creek.

Access to the creek is controlled by private landowners and not readily available to the public. From May 1975 through April 1976, O'Dell Creek provided an estimated 706 fisherman days of recreation (MDFG 1976).

Waterfowl

Use of the creek by ducks is extensive during the fall and winter months. Canada geese, blue-winged teal, and mallards commonly nest along the creek.

Wildlife

Big game animals found along the creek are moose, mule deer, and white-tailed deer. Upland game birds present include ruffed grouse, Hungarian partridge and an occasional ring-necked pheasant.

Environmental Concerns

The destruction of streambank vegetation due to overuse by cattle is a major concern. Bank vegetation is important to the aquatic habitat because it provides overhanging cover for trout and stabilizes the streambanks, preventing bank erosion and the resulting stream sedimentation and widening of the channel.

Method Used For Flow Recommendations

See page 123.

Flow Recommendations

See page 123.

1. SPRING CREEK

Poindexter Slough

2. GENERAL DESCRIPTION

Poindexter Slough (Figure 32) is a meandering, spring-fed stream located about 3 miles southwest of Dillon, Montana and is approximately 4 miles in length. Flow varies from about 30 cfs to 100 cfs and is partially influenced by the Beaverhead River. A headgate, constructed in the 1930's by the Dillon Canal Company, regulates inflow of water from the Beaverhead River during the irrigation season (May through October). A "closed tile drainage system" was constructed in the headwater area during 1971 through a contract funded by the U.S. Bureau of Reclamation (Peterson 1973) and has probably changed the flow pattern of the stream. The most common bottom type is gravel although in many areas the bottom is covered with a thick layer of sediment.

3. REACH #1

From the mouth of the headwaters.
(T7S, R9W, Sec. 26 to T8S, R9W, Sec. 10)

Description

See GENERAL DESCRIPTION

Fishery

Spring creeks in general provide unique fisheries and Poindexter is no exception. Biologically, this stream is extremely productive and supports between 350 and 800 trout per 1,000 ft of stream (Elser 1969, Elser and Marcoux 1971 and Peterson 1975). Brown trout are the dominant species followed by rainbow and brook trout. Other species present include mountain whitefish, longnose dace, carp, burbot (ling), long-nose sucker, common sucker, mountain sucker and mottled sculpin. In addition to resident fish populations, Poindexter Slough provides spawning habitat for trout from the Beaverhead River.

Poindexter Slough is an extremely popular fishing stream. From May 1975 through April 1976, it provided an estimated 2,625 fisherman days of recreation (MDFG 1976).

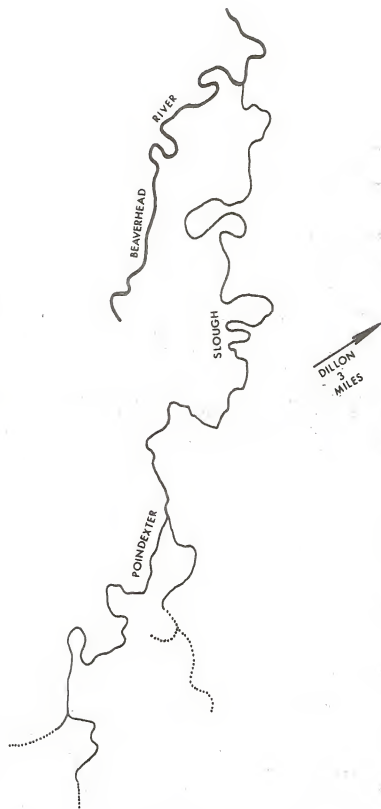


Figure 32. Map of Poindexter Slough.

Waterfowl

Waterfowl use this stream extensively especially after freeze-up of local ponds and lakes. Poindexter Slough is a popular duck hunting area.

Wildlife

White-tailed deer are found along the riparian zones of Poindexter Slough. Furbearers present include mink, beaver and muskrat.

Environmental Concerns

While Poindexter Slough continues to be productive biologically, it is threatened by increased sedimentation. Sediment input due to streambank trampling by livestock and overgrazing in the headwater area has combined with sediment input from the Beaverhead River during high flow periods to reduce aquatic habitat. An additional problem appears to be possible decreases in groundwater flow with increases in sprinkler irrigation in the headwater area.

Method Used For Flow Recommendations

See page 123.

Flow Recommendations

See page 123.

1. SPRING CREEK

Thompson Creek

2. GENERAL DESCRIPTION

Thompson Creek (Figure 30) is located in the Gallatin valley north of Belgrade, Montana. It flows 6.8 miles in a northerly direction before entering the East Gallatin River. Flows are relatively constant due to its spring creek nature. On February 6, 1979 an instantaneous flow of 19 cfs was measured near the mouth and a flow of 8 cfs was measured in a middle reach. No irrigation diversions occur on the creek. The gradient is 14.8 ft per mile. The land adjacent to Thompson Creek is used for cattle grazing and hay production. The streambanks are either vegetated with willow and alder or open due to intense cattle use. Overuse by cattle has caused extensive bank erosion.

Physical measurements were made on a 300 ft section of creek located about midway between the mouth and headwaters in 1979. The mean channel width was 30 ft and the mean thalweg depth was 0.8 ft. About 6% of the creek bottom consisted of exposed gravel-cobble while the remainder was covered with a layer of sediment ranging from 0.1 to 2.0 ft in thickness.

3. REACH #1

From the mouth to the headwaters
(T1N, R4E, Sec. 13 to T1N, R5E, Sec. 31)

Description

See GENERAL DESCRIPTION

Fishery

Rainbow trout, brown trout and an occasional brook trout comprise the sport fishery in Thompson Creek. Brown and rainbow trout occasionally reach weights of 4 to 5 pounds, but few exceed 2 pounds. In 1968 the estimated number of 6 inch and larger rainbow and brown trout was 226 and 167, respectively, per mile of creek (Vincent 1968). The estimated biomass of trout was 150 pounds per mile. Preliminary results for an estimate made in 1979 showed the trout population to be about half of that in 1968.

Access is controlled by private landowners and not readily available to the public. Between May 1975 and April 1976, Thompson Creek provided an estimated 53 fisherman days of recreation (MDFG 1976).

Waterfowl

Heavy waterfowl use occurs during the fall and winter months. Common nesting waterfowl are blue-winged teal and mallard.

Wildlife

Big game animals found along the creek are mule deer and white-tailed deer. Upland game birds include Hungarian partridge and ring-necked pheasant. The greater sandhill crane is commonly observed during the summer.

Environmental Concerns

The destruction of streambank vegetation due to overuse by cattle has eliminated much of the trout habitat in Thompson Creek. Eroding, unstable banks have resulted in the widening and the filling in of the channel with sediments. The end result is a wide, shallow channel having little overhead cover for trout and lacking the clean gravel areas needed for trout reproduction and the production of trout food. The decline of the trout fishery in the past 10 years is undoubtedly related to the problems created by cattle overuse.

Method Used For Flow Recommendations

See page 123.

Flow Recommendations

See page 123.

1. RIVER

Missouri River between Canyon Ferry Reservoir and the headwaters

2. GENERAL DESCRIPTION

The following discussion and flow recommendations only pertain to the upper 45.5 miles of the Missouri River from its origin at the junction of the Madison, Gallatin, and Jefferson rivers to Canyon Ferry Reservoir (Figure 33). This section includes 20 miles of "Blue Ribbon" water.

The drainage area is 14,669 square miles (at Toston). Width of the channel ranges from 300 to 1,200 ft. The average gradient is 5.6 ft per mile and sinuosity is 1.6. The substrate ranges from sand-silt to cobble, but the majority is gravel-cobble.

Tributaries entering the Missouri in this section originate mainly from the east and most are totally diverted during the late summer for irrigation. The tributaries are Deep, Dry, Sixmile, Indian, Crow, Sixteenmile and Greyson creeks.

The natural flow patterns in this section have been impacted by three upstream impoundments - Hebgen Reservoir on the Madison River, Ruby Reservoir on the Ruby River and Clark Canyon Reservoir on the Beaverhead River. This section of the Missouri is immediately affected by Canyon Ferry Dam, a power production and flood control structure, and Toston Dam, principally an irrigation storage reservoir. Toston Dam does not allow total regulation because of its small size.

The mean flow for a 42-year period of record at the USGS gage at Toston was 5,371 cfs. Flows ranged from 562 to 32,000 cfs. High water flows normally occur from April through July with peak flows occurring in June.

This section of river has good access for the recreationist. Public access points are especially well placed for floaters. These points include the Headwaters State Park at Three Forks, the Toston fishing access site, the Deepdale fishing access site, and the Townsend access. Floating is popular during the fall when excellent fishing for salmonids exists as well as good waterfowl hunting.

Riparian vegetation is limited to a narrow band along the river except for the lower 10 miles above Canyon Ferry Reservoir. In this area, the river channel is braided and the bottomland is extensively vegetated with willow and cottonwood.

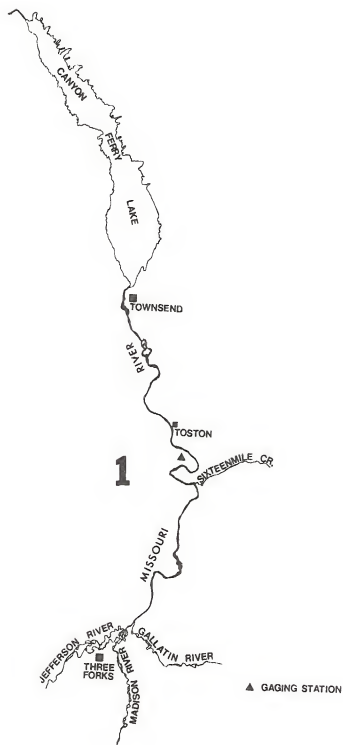


Figure 33. Map of the Missouri River between the headwaters and Canyon Ferry Reservoir.

A 1969 state law (Section 89-801, R.C.M. 1947) authorized the Montana Department of Fish and Game to appropriate water for instream uses on twelve rivers in the state. On the Missouri River between Canyon Ferry Reservoir and Toston Dam, the "Blue Ribbon" portion of the river, the department appropriated 3,000 cfs from September 15 to May 15 and 4,000 cfs from May 16 to September 14.

3. REACH #1

From Canyon Ferry Reservoir to the confluence of the Gallatin, Madison, and Jefferson rivers.
(T7N, R2E, Sec. 30 to T2N, R2E, Sec. 17)

Description

See GENERAL DESCRIPTION

Fishery

Reach #1 of the Missouri River is nationally known for producing trophy size rainbow and brown trout. Currently, a creel census is being conducted on the "Blue Ribbon" portion between Canyon Ferry Reservoir and Toston Dam. Results show that rainbow and brown trout in the 17 to 22 inch class were commonly taken in 1978 with one brown trout reaching 8 pounds.

Population studies conducted during the fall of 1978 showed that large brown trout were present in the Toston Bridge to Deepdale area. Ten of the brown trout collected were over 5 pounds. Over 500 rainbow were sampled in the area from Townsend to Canyon Ferry Reservoir with many in the 17 to 20 inch class. In addition to substantial trout populations, reach #1 also supports large numbers of mountain whitefish. Other fish present and their relative abundance are:

Cutthroat trout	rare
Brook trout	rare
Yellow perch	rare
Flathead chub	rare
Longnose dace	rare
Carp	abundant
White sucker	abundant
Longnose sucker	abundant
Stonecat	common

In addition to resident fish populations, the Missouri River from Canyon Ferry Reservoir to Toston Dam provides spawning and nursery areas for trout residing in the reservoir. Both brown and rainbow trout migrate into the river each fall, producing a trophy fishery. The fall run of rainbow trout produces an outstanding fishery. During the fall of 1978, 40% of the anglers censused had weight limits of rainbow trout (10 pounds plus one fish). Of a sample of 2,500 rainbow trout in the creel, 40% were in the 17 to 19 inch class with a few ranging to 25 inches and 8 pounds. Trout from

the reservoir have excellent growth with rainbow trout reaching an average of 15.8 to 17.1 inches at the third annulus (Heaton 1961). Fishing during this fall run is popular with both resident and nonresident anglers.

Between May 1975 and April 1976, the estimated fishing pressure for reach #1 in fisherman-days was 7,705 (MDFG 1976).

Waterfowl

Waterfowl use reach #1 during fall and spring migrations. That portion of the river just above Canyon Ferry Reservoir harbors extensive numbers of nesting ducks and geese. The river islands are primarily used for nesting by Canada geese. The security of nesting islands has been shown to be directly dependent on river flow.

Wildlife

Whitetail deer and ring-necked pheasant are abundant in the bottomland along reach #1. Other wildlife of particular interest are golden and bald eagles (both resident and migratory), osprey (6 to 7 nesting pairs), great blue heron (two large rookeries), and whistling and trumpeter swans (migratory). Furbearers include beaver, mink, muskrat and river otter. Common predators are red fox, coyote and raccoon.

Environmental Concerns

Aquatic habitat conditions are generally good throughout reach #1. River banks are stable and well vegetated. The dewatering of the river due to irrigation withdrawals is an occasional problem. The sediment input of tributaries and irrigation return flows in the Toston to Deepdale area is excessive. Elevated water temperatures are also a concern. Though the temperature data is not extensive, many days at 70 F and higher have been recorded (USGS, 1973-1976). Temperatures above 70 F are generally considered undesirable for trout.

A potential problem is the conversion of Toston Dam to hydroelectric generation. Flow fluctuations resulting from this conversion could have a serious impact on the reproductive success of trout. The river between Toston Dam and Canyon Ferry Reservoir is extensively used as a spawning and nursery area by brown and rainbow trout from the reservoir. Flow fluctuations resulting from hydroelectric generation should be avoided. Plans for changing the structure of Toston Dam should also include a fish passage facility.

Method Used For Flow Recommendations

Flow recommendations during the high water period (April 16 - July 15) are based on the dominant discharge/channel morphology concept (see page 5) and obtained from data supplied by the USGS (1978). The 1½ year frequency peak flow was used to approximate the bank full condition.

Flow recommendations for the remainder of the year are based solely on the instream flows appropriated under state law by the Montana Department of Fish and Game (see GENERAL DESCRIPTION). As methodologies are developed, additional information will be gathered to justify these flow recommendations.

Flow Recommendations

The bank full flow, estimated at 15,433 cfs, should be established for 24 hours during June 1-15. During the remainder of the high water period (April 16 - July 15), the 70% exceedance flows are recommended (see page 5).

The recommended instream flows for reach #1 of the Missouri River are identified in Table 24. The recommended flows amount to 2.88 MAF per year. For all months, except August, the mean monthly flows exceed the recommended flows. The mean monthly flow for August reflects the dewatering of the river for irrigation. The recommended and mean flows for September are about equal.

Table 24. Recommended instream flows compared to mean monthly flows for reach #1 of the Missouri River.

Time Period	Instream Flow		Mean	
	CFS	AF	CFS	AF
January	3,000	184,419	3,335	205,012
February	3,000	166,572	3,749	208,159
March	3,000	184,419	4,129	253,822
April 1-15	3,000	89,235	5,828	346,708
April 16-30	4,228	125,762		
May 1-15	5,123	152,384	8,971	551,474
May 16-31	6,872	218,035		
June 1-15	9,219	286,542 ^{1/}	13,180	784,078
June 16-30	6,802	202,325		
July 1-15	4,795	142,627	5,425	333,491
July 16-31	4,000	126,912		
August	4,000	245,892	2,848	175,075
September 1-15	4,000	118,980	3,533	210,178
September 16-30	3,000	89,235		
October	3,000	184,419	4,445	273,247
November	3,000	178,470	4,711	280,257
December	3,000	184,419	3,801	233,659
Total		2,880,647		3,855,160

^{1/} Includes a flow of 15,433 cfs for 24 hours.

1. STREAM

Sixteenmile Creek

2. GENERAL DESCRIPTION

Sixteenmile Creek originates in the foothills of the Crazy Mountains in southwestern Montana at an elevation of approximately 6,000 ft (Figure 34). From its headwaters, it flows southwesterly about 55 miles to its mouth, joining the Missouri River 4 miles upstream from Toston Dam. The average gradient is 37 feet per mile. USGS gage records for a 5 year period (1950 to 1955) indicate that high water flows occur during April, May and June.

The landscape of Sixteenmile Creek consists of timbered foothills and sagebrush-grassland hills in the upper reach, and willow and hay fields alternating with steep limestone canyons in the middle and lower reaches. Agriculture in the area consists primarily of cattle ranching with associated hay crops and some grain farming.

Several small irrigation reservoirs are located in the headwaters. The largest is located on a tributary about 3 miles upstream from Ringling and stores 700 acre-feet to serve 2,400 acres of cropland. There is also a small onstream reservoir located at Sixteen. In addition, water is pumped from Sixteenmile Creek to sprinkle irrigate hayfields in its middle reach near Francis.

Dewatering has had a minimal affect on the lower and middle reaches of Sixteenmile Creek. However, its upper reach can become completely dewatered in late summer.

Habitat on portions of Sixteenmile Creek has suffered due to man's activities. Along most of its length, cattle use of the bottomland has caused local streambank instability and may affect the vigor of streambank vegetation.

Except for areas heavily used by cattle, the upper half of Sixteenmile Creek from its headwaters to the Middle Fork of Sixteenmile Creek has a relatively stable meandering stream channel. In its lower reaches, stream channel stability and habitat have deteriorated due to mechanical straightening of the channel to accommodate the Milwaukee Railroad bed.

Sixteenmile Creek supports a diverse wild trout fishery. Its middle reaches maintain a particularly outstanding trout population. Brook trout is the dominant trout in the headwaters, rainbow trout is dominant in the middle reaches and brown trout is dominant in the lower reaches. Other game fish present are mountain whitefish and what appears to be a pure strain of Missouri River cutthroat trout. Nongame fish include mottled sculpin, longnose sucker and white sucker.

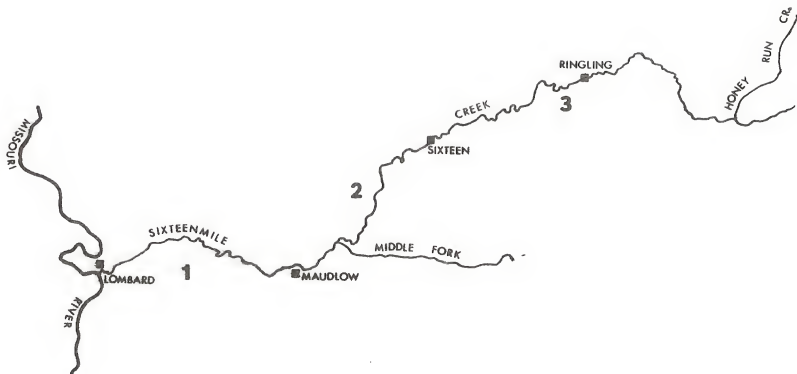


Figure 34. Map of Sixteenmile Creek.

Nearly all of Sixteenmile Creek flows through private lands. However, fishermen access with permission from the landowners is good.

Sixteenmile Creek is relatively remote. Poor roads, together with rough terrain, make physical access to Sixteenmile Creek difficult. Access is gained from the west to the lower reaches of the stream by way of Toston and from the south to the middle reaches across 40 miles of secondary roads to Maudlow. A roadless area between Maudlow and Toston limits access in this area. Access from the east to the upper and middle reaches is gained by way of Ringling located on Montana Highway 89. Further access is possible from the north by way of Montana Highway 12 across 12 miles of county road to Sixteen.

In addition to the excellent trout fishery, the Sixteenmile Creek drainage supports diverse populations of game animals and game birds as well as many furbearers and nongame animals. Populations of game animals include elk, mule deer, whitetail deer, pronghorn antelope, black bear and mountain lion. Upland game birds present include sage grouse sharp-tailed grouse, Hungarian partridge and ring-necked pheasant. Mountain grouse are also present, including blue grouse, ruffed grouse and spruce grouse. Furbearers found in the drainage include raccoon, beaver, muskrat, mink, weasel, martin, badger, wolverine, bobcat, lynx, red fox and coyote. Nongame animals such as ground squirrel, porcupine, rabbit, snakes and song birds are plentiful. Various raptors are also found including the bald eagle, golden eagle, rough-legged hawk, Swainson's hawk, red-tailed hawk, osprey and sparrow hawk.

Sixteenmile Creek is located in the pacific migratory bird flyway. Its drainage and the adjacent prairie pothole country play host to many species of waterfowl during spring and fall migrations. A smaller number of "local" waterfowl remain all year. The most common waterfowl species found include the mallard, pintail, gadwall, shoveler, teal, Canada goose, and snow goose.

3. REACH #1

From the mouth to the Middle Fork of Sixteenmile Creek.
(T4N, R3E, Sec. 18 to T4N, R5E, Sec. 4)

Description

Reach #1 of Sixteenmile Creek flows approximately 19 miles through sagebrush-grassland hills and steep limestone canyons. The gradient is about 29 feet per mile. Cattle ranching is the primary agricultural activity.

Measurements made on 2,100 ft of stream at the upper end of the reach, just downstream from the Middle Fork of Sixteenmile Creek, showed an average width of 33.0 ft and an average depth of 1.1 ft. Measurements made on 3,750 ft of stream near the mouth showed the average width and depth were 35.0 and 1.1 ft, respectively.

The stream channel in reach #1 is unstable primarily due to considerable straightening to accommodate the Milwaukee Railroad bed. Overuse by cattle contributes to the unstable condition but is secondary to stream channel alterations. A section of stream that was 4,050 ft in length before straightening, measured 2,555 ft after straightening for a 36.9% reduction in stream length. In addition, stream measurements to determine the extent of bank erosion showed 34.3% of 31,000 ft of bank were eroded.

Fishery

Fish populations were monitored at two study sections between 1970 and 1974. The upper study section is located just below the mouth of the South Fork of Sixteenmile Creek and the lower study section is about 2 miles upstream from the mouth of Sixteenmile Creek.

At the upper study section in September 1974, standing crops of brown and rainbow trout per 1,000 ft were 32 and 29 pounds, respectively. Number estimates for brown and rainbow trout were 55 and 79, respectively. At the lower study section in March 1974, standing crops of brown and rainbow trout per 1,000 ft were 15 and 2 pounds, respectively. Number estimates for brown and rainbow trout were 38 and 5, respectively.

Due to generally poor habitat conditions caused by extensive stream alterations, only a fraction of the potential aquatic productivity is being realized. However, there is a large potential to improve the habitat and fishery of this reach by allowing the channel to regain its natural length and stabilize.

Wildlife

This reach of Sixteenmile Creek supports diverse populations of game animals and game birds as well as many furbearers and nongame animals. Populations of game animals include elk, mule deer, white-tailed deer, pronghorn antelope, black bear and mountain lion.

Upland game birds present include sage grouse, sharp-tailed grouse, Hungarian partridge and ring-necked pheasant. Mountain grouse are also present including blue grouse, ruffed grouse and spruce grouse. Furbearers found along this reach include raccoon, beaver, muskrat, mink, weasel, badger, bobcat, lynx, red fox and coyote. Nongame animals such as ground squirrel, porcupine, rabbit, snakes and song birds are plentiful. Various raptors are also found including the bald eagle, golden eagle, rough-legged hawk, Swainson's hawk, red-tailed hawk, osprey and sparrow hawk.

Waterfowl

Reach #1 of Sixteenmile Creek is located in the pacific migratory bird flyway. Its drainage and the adjacent prairie pothole country play host to many species of waterfowl during spring and fall migrations. A smaller number of "local" waterfowl remain all year. The most common species found include the mallard, pintail, gadwall, shoveler, teal, Canada goose, and snow goose.

Environmental Concerns

Stream channel stability and habitat have suffered greatly in reach #1 primarily due to mechanical straightening of the channel as well as overuse by cattle (see Description and Fishery).

Method Used For Flow Recommendations

Field measurements for flow recommendations for reach #1 of Sixteenmile Creek have not been made. Future instream flow recommendations will be made for two periods during the year. The dominant discharge/channel morphology concept (see page 5) will be used for the period of high flow. For this report, the period of high flow (April 1 - June 30) is based on a USGS record for a 5 year period (1950-1955) at Ringling. For the remainder of the year, the wetted perimeter method will be used to identify the low and high levels of aquatic habitat potential.

Flow Recommendations

The bank-full flow (not yet determined) should be maintained for a 24 hour period sometime during the high flow period (April 1 - June 30). For the remainder of the high flow period, the 70% exceedance flow (undetermined due to inadequate flow records) is recommended. Flows corresponding to the high level of aquatic habitat potential (currently undetermined) are recommended for the remainder of the year (July 1 - March 31). Since the drainage area of this reach is larger, flow recommendations will exceed those of the upstream reaches.

4. REACH #2

Middle Fork Sixteenmile Creek to Sixteen
(T4N, R5E, Sec. 4 to T5N, R6E, Sec. 5)

Description

Reach #2 of Sixteenmile Creek flows approximately 11 miles through rugged limestone canyons, sagebrush-grassland hills and hay meadows. Average gradient is 41 feet per mile. Cattle ranching and associated hay production are the primary agricultural activities.

Stream measurements made on 3,000 ft of stream 2 miles upstream from Francis showed the average width and depth were 31.5 and 1.2 ft, respectively. Measurements made on 3,700 ft of stream just downstream from Francis showed similar average width and depth at 32.4 and 1.2 ft, respectively.

The stream channel in this reach has not been altered and is relatively stable except for localized stream bank disturbance due to cattle use. Stream measurements to determine the extent of bank erosion showed only 6.5% of 13,400 ft of bank were eroded compared to 34.3% of 31,000 ft of bank within reach #1.

Presently water is pumped from Sixteenmile Creek near Francis for sprinkler irrigation of hay meadows.

Fishery

In the fall of 1969, an extensive fish kill resulted when a cattle dip tank containing a toxaphene base solution was emptied into the stream near Francis. Fish populations appear to have recovered from the poisoning. Reach #3 presently supports an outstanding wild trout population.

Fish populations were monitored at two study sections between 1970 and 1974. The upper study section is located about 2 miles upstream from Francis and the lower one is just downstream from Francis.

In the upper study section in September 1974, standing crops of rainbow and brown trout per 1,000 ft were 143 and 46 pounds, respectively. Number estimates of rainbow and brown trout were 325 and 91, respectively. In the lower study section, standing crops of rainbow and brown trout per 1,000 ft were 154 and 78 pounds, respectively. Number estimates of rainbow and brown trout were 302 and 152, respectively. What appears to be a pure strain of Missouri River cutthroat is also found in reach #2 along with mottled sculpin and small populations of mountain whitefish, longnose sucker, and white sucker.

Reach #2 is popular with fishermen. All of the access is controlled by the Climbing Arrow Ranch. The ranch allows access to fish the stream with fly fishing, barbless hooks only restrictions and encourages catch and release fishing.

Wildlife

In addition to the excellent trout fishery, the area surrounding reach #2 supports diverse populations of game animals and game birds as well as many furbearers and nongame animals. Populations of game animals include elk, mule deer, whitetail deer, pronghorn antelope, black bear and mountain lion. Upland game birds present include sage grouse, sharp-tailed grouse, Hungarian partridge and ring-necked pheasant. Mountain grouse are also present including blue grouse, ruffed grouse and spruce grouse. Furbearers found in the drainage include raccoon, beaver, muskrat, mink, weasel, martin, badger, wolverine, bobcat, lynx, red fox and coyote. Nongame animals such as ground squirrel, porcupine, rabbit, snakes and song birds are plentiful. Various raptors are also found including the bald eagle, golden eagle, rough-legged hawk, Swainson's hawk, red-tailed hawk, osprey and sparrow hawk.

Waterfowl

Same as reach #1.

Environmental Concerns

Localized streambank disturbance from overuse by cattle (see GENERAL DESCRIPTION and Description).

Method Used For Flow Recommendations

Flow recommendations for the period of high flow (April 1 - June 30) will be based on the dominant discharge/channel morphology concept (see page 5). Surveyed cross-sections, photographs, flow measurements and field observations were used to determine the bank full flow (Workman 1976).

For the remainder of the year (July 1 - March 31), the wetted perimeter method was used to derive the flows maintaining low and high levels of aquatic habitat potential. The relationship between wetted perimeter and flow for a composite of 18 cross-sections in reach #2 was generated using the WSP computer program (see page 7). The 18 cross-sections were located just downstream from Francis (T5N, R5E, Sec. 34).

Flow Recommendations

The bank full flow (500 cfs) should be established for 24 hours sometime during high flow (April 1 - June 30). For the remainder of the high flow period, the 70% exceedance flow (undetermined due to inadequate flow records) is recommended.

The relationship between wetted perimeter and flow for a composite of 18 cross-sections is shown in Figure 35. As indicated in Figure 35, two inflection points occur at 50 and 125 cfs and correspond to the low and high levels of aquatic habitat potential, respectively (see page 7).

Instream flows that will maintain stream channel morphology and a low and high level of aquatic habitat potential are partially identified in Table 25. The instream flows recommended for reach #2 of Sixteenmile Creek correspond to the high level of aquatic habitat potential. There is no comparison with mean flows due to inadequate stream flow records.

5. REACH #3

From Sixteen to Honey Run Creek
(T5N, R6E, Sec. 5 to T6B, R9E, Sec. 35)

Description

Reach #3 of Sixteenmile Creek, approximately 25 miles in length, flows through the foothills of the Crazy Mountains, sagebrush-grassland hills, rugged limestone canyons and farmland. The gradient of the headwaters is 70 feet per mile while that of the remainder of the reach is 29 feet per mile. In portions of reach #3, Sixteenmile Creek is a meandering meadow stream.

There are several small reservoirs located in the headwaters. The largest, located on a tributary to Sixteenmile Creek 3 miles upstream from Ringling, stores 700 acre-feet of water to irrigate about 2,400 acres of cropland. In addition, there is a small onstream reservoir just upstream from Sixteen.

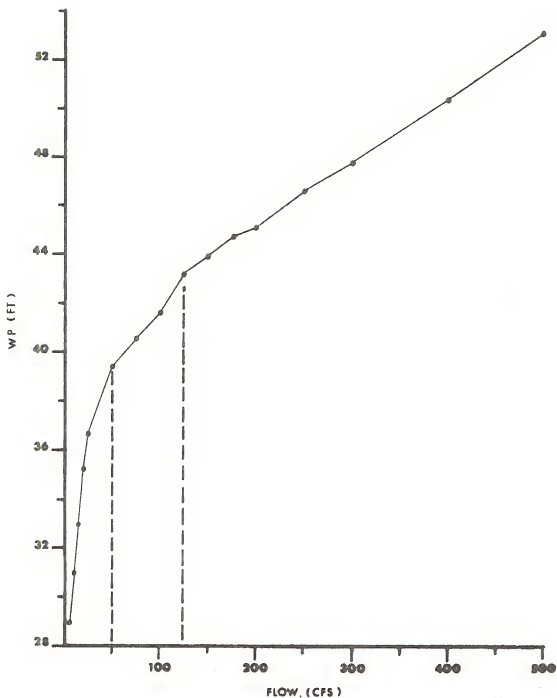


Figure 35. The relationship between wetted perimeter and flow for a composite of 18 cross-sections in reach #2 (from Middle Fork of Sixteenmile Creek to Sixteen) of Sixteenmile Creek.

Table 25. Instream flows representing low and high levels of aquatic habitat potential for reach #2 of Sixteenmile Creek.

Time Period	Flow			
	Low 1/ CFS	AF	High 2/ CFS	AF
January	50	3,074	125	7,686
February	50	2,777	125	6,942
March	50	3,074	125	7,686
April	3/		3/	
May	3/		3/	
June	3/		3/	
July	50	3,074	125	7,686
August	50	3,074	125	7,686
September	50	2,975	125	7,438
October	50	3,074	125	7,686
November	50	2,975	125	7,438
December	50	3,074	125	7,686

1/ Low level of aquatic habitat potential.

2/ High level of aquatic habitat potential.

3/ Flows presently unidentified.

USGS gage records for a 5 year period (1950 to 1955) at Ringling show that discharge from year to year can be highly variable. The maximum discharge for each water year ranged from 26 cfs in April 1954 to 347 cfs in April 1952. Mean flow for the 1951 through 1954 water years ranged from 4 cfs in 1954 to 29 cfs in 1952. These records also show that no measurable flow occurred in Sixteenmile Creek at Ringling during 8 consecutive days from August 27 to September 3, 1954 indicating that during low water years severe damage to the aquatic biota can occur.

Fishery

This upper reach of Sixteenmile Creek supports a good wild trout fishery with brook trout the dominant species. Brown trout are also common with occasional rainbow trout present. Sculpin, white sucker and what appears to be Missouri River cutthroat are also present.

Physical access to reach #3 is good except during inclement weather. Fisherman access with permission from the landowner is good.

Wildlife

Same as reach #2

Waterfowl

Same as reach #2

Environmental Problems

Dewatering may be severe during low water years (see Description). Localized streambank disturbance from overuse by cattle also occurs.

Method Used For Flow Recommendations

Flow recommendations for the period of high flow (April 1 - June 30) will be based on the dominant discharge/channel morphology concept (see page 5). Surveyed cross-sections, photographs, flow measurements and field observations were used to determine the bank full flow. For the remainder of the year (July 1 - March 31), the wetted perimeter method was used to derive the flows needed to maintain the low and high levels of aquatic habitat potential. The relationship between wetted perimeter and flow for a composite of six cross-sections was generated using the WSP computer program (see page 7). The six cross-sections were located just downstream from Ringling (T6N, R7E, Sec. 22).

Flow Recommendations

The bank full flow (100 cfs) should be established for 24 hours sometime during the period of high flow (April 1 - June 30).

For the remainder of the high flow period, the 70% exceedance flow (undetermined due to inadequate flow records) is recommended.

The relationship between wetted perimeter and flow for a composite of six cross-sections is shown in Figure 36. As indicated in Figure 36, two inflection points occur at 5 and 15 cfs and correspond to the low and high levels of aquatic habitat potential, respectively (see page 7).

Instream flows that will maintain stream channel morphology and a low and high level of aquatic habitat potential are partially identified in Table 26. The instream flow recommended for reach #3 of Sixteenmile Creek correspond to the high level of aquatic habitat potential. There is no comparison with mean flows due to inadequate stream flow records.

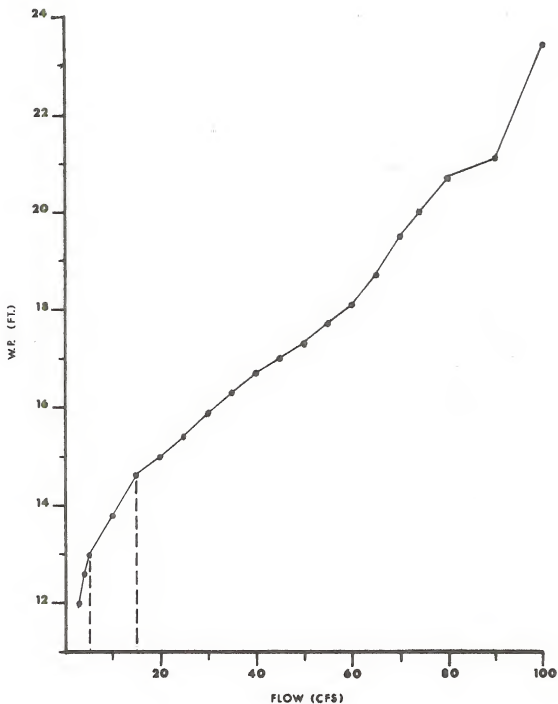


Figure 36. The relationship between wetted perimeter and flow for a composite of six cross-sections in reach #3 (from Sixteen to Honey Run Creek) of Sixteenmile Creek.

Table 26. Instream flows representing low and high levels of aquatic habitat potential for reach #3 of Sixteenmile Creek.

Time Period	Flow			
	Low 1/ CFS	AF	High 2/ CFS	AF
January	5	307	15	922
February	5	278	15	833
March	5	307	15	922
April	3/		3/	
May	3/		3/	
June	3/		3/	
July	5	307	15	922
August	5	307	15	922
September	5	298	15	893
October	5	307	15	922
November	5	298	15	893
December	5	307	15	922

1/ Low level of aquatic habitat potential.

2/ High level of aquatic habitat potential.

3/ Flows presently unidentified.

1. STREAM

Prickly Pear Creek

2. GENERAL DESCRIPTION

Prickly Pear Creek (Figure 37) originates in the Elkhorn Mountains at an elevation of 6,800 ft. It flows north for approximately 42 miles to the Missouri River. Immediately upstream from the confluence with the Missouri River, Prickly Pear Creek is impounded to form Lake Helena. The Montana Department of Health classifies the lower portion of the stream (below East Helena) for agricultural and industrial use only. The upper portion (above East Helena) is classified to include growth and propagation of salmonid fishes and associated aquatic life.

The upper portion of Prickly Pear Creek, which supports an excellent small stream trout fishery, averages 24 feet in width. The channel meanders through a relatively stable floodplain with its substrate mainly comprised of gravel and cobble. This reach has five principal tributaries: Beavertown, Clancy, Lump Gulch, Spring and McCellan creeks.

The mean flow for a 43-year period of record for the USGS gage near Clancy was 48.3 cfs. Flows ranged from 0.5 to 900 cfs. High water occurs from May through June with peak flows occurring in June.

Prickly Pear Creek is an important fishery to residents of the Helena area. Between May 1975 and April 1976, fishing pressure in fisherman days was estimated at 1,049 (MDFG 1976). This constitutes substantial use of a stream this size and illustrates the importance of maintaining the fishery.

3. REACH #1

From the Highway 12 bridge in East Helena to the headwaters. (T10N, R3W, Sec. 25 to T7N, R2W, Sec. 19).

Description

See GENERAL DESCRIPTION

Fishery

Game fish present in Prickly Pear Creek are rainbow trout, brown trout, brook trout, cutthroat trout and mountain whitefish. Nongame fish include white sucker, longnose sucker, mottled sculpin and longnose dace.

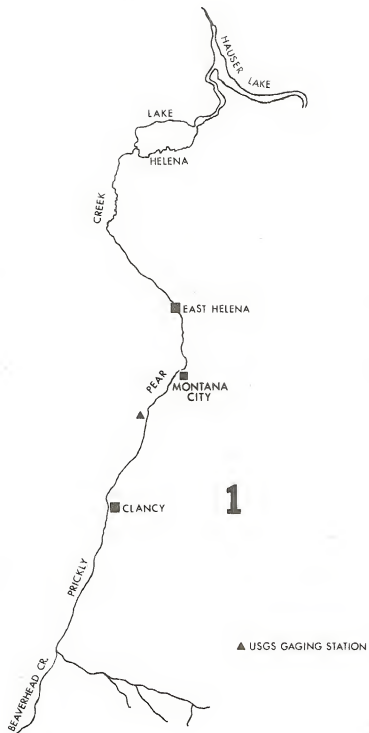


Figure 37. Map of Prickly Pear Creek.

Trout population estimates were made in 1967 through 1972 and 1974 (Elser 1969 and Workman 1972, 1973, 1974). This work was done in conjunction with stream alterations made during construction of I-15. The 1972 estimate showed 660 trout (rainbow and brown trout combined) per mile of stream. The 1974 population had recovered to the level of preconstruction and was 1,070 trout per mile. The trout population was 53% brown trout and 47% rainbow trout. The rainbow trout ranged from 5 to 11 inches while the brown trout ranged from 5 to 18 inches. Both populations are self-sustaining.

Waterfowl

Waterfowl use this stream as a nesting and rearing area primarily in the spring and early summer. Nesting waterfowl include mallard, blue-winged teal, and common merganser. Canada geese are occasionally observed.

Wildlife

The narrow band of riparian vegetation along Prickly Pear Creek supports resident white-tailed deer and wintering mule deer. The upper portion of the drainage supports a resident moose population and wintering elk herds inhabit areas adjacent to the stream. The Hungarian partridge is the primary game bird along the creek. Sharp-tailed grouse also inhabit the area in limited numbers. Other wildlife present include red fox, coyote, black bear, porcupine, marsh hawk and golden eagles. Furbearers include beaver, muskrat and mink.

Environmental Concerns

For many years periodic water quality problems occurred in Prickly Pear Creek. Causes have included sedimentation from gold dredging and highway construction, sewage pollution, thermal and metals pollution from the ASARCO plant in East Helena, and waste materials entering the stream from the Kaiser Cement Plant at Montana City. Presently, the point sources of the pollution problems above East Helena have been corrected. Although 51% of the stream channel has been altered (Bishop and Peck 1962), the unaltered and to a lesser extent the altered sections still provide good physical habitat conditions for aquatic life. Extensive dewatering, particularly below East Helena, severely limits the fishery in portions of the creek.

Method Used For Flow Determinations

The wetted perimeter method was used to identify the low and high levels of aquatic potential (see page 7 for detailed explanation) during July 1 through April 30. Five cross-sections on Prickly Pear Creek were surveyed (T9W, R3W, Sec. 23). The wetted perimeter projections at various flows were generated by the IFG4 computer program.

Flow recommendations for the high water period (May 1 - June 30) are based on the dominant discharge/channel morphology concept (see page 5) and obtained from data supplied by the USGS (1978). The 1 $\frac{1}{2}$ -year frequency peak flow was used to approximate the bankfull condition.

Flow Recommendations

The relationship between wetted perimeter and flow for a composite of five cross-sections in reach #1 is shown in Figure 38. The two inflection points identified in the figure occur at flows of approximately 15 and 30 cfs and correspond to the low and high level of aquatic habitat potential, respectively.

The bankfull flow, estimated at 202 cfs, should be established for 24 hours during May. For the remainder of the high water period (May 1 - June 30), the 70% exceedance flows are recommended (see page 5).

Instream flows which will maintain a low and high level of aquatic habitat potential are identified in Table 27. Instream flows recommended for reach #1 of Prickly Pear Creek correspond to the high level of aquatic habitat potential and amount to 27,052 acre-feet annually. For the months of August through March, the recommended instream flow were about equal to or slightly greater than the mean monthly flows (Table 27). This indicates that any additional withdrawals of water during these months could be harmful to the aquatic resource.

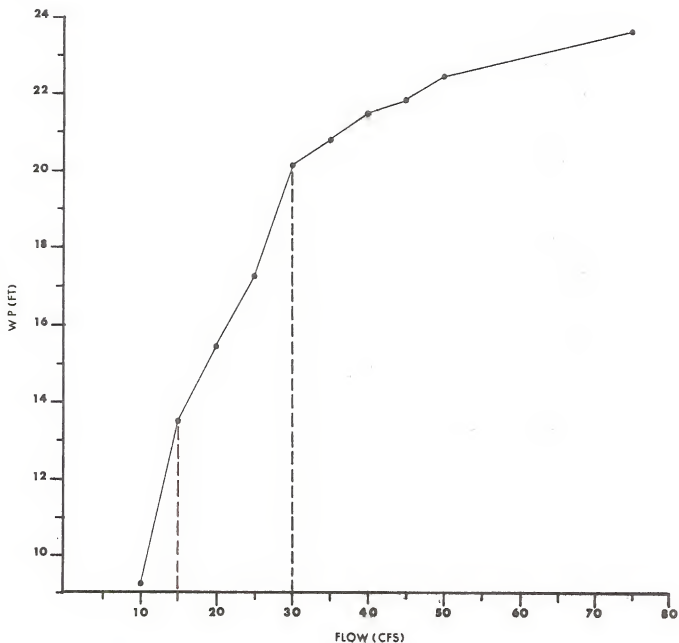


Figure 38. The relationship between wetted perimeter and flow for a composite of 5 cross-sections in reach #1 (from East Helena to the headwaters) of Prickly Pear Creek.

Table 27. Instream flows representing low and high levels of aquatic habitat potential compared to mean monthly flows for reach #1 of Prickly Pear Creek.

Time Period	Flow					
	Low <u>1/</u>		High <u>2/</u>		Mean	
	CFS	AF	CFS	AF	CFS	AF
January	15	922	30	1,844	21.1	1,297
February	15	833	30	1,666	24.0	1,333
March	15	922	30	1,844	31.6	1,943
April	15	892	30	1,785	53.7	3,195
May 1-15	62	1,844	62	1,844		
May 16-31	90	3,078 ^{3/}	90	3,078 ^{3/}	109	6,701
June 1-15	76	2,261	76	2,261		
June 16-30	58	1,725	58	1,725	139	8,269
July	15	922	30	1,844	57.4	3,529
August	15	922	30	1,844	29.4	1,807
September	15	892	30	1,844	29.1	1,731
October	15	922	30	1,844	31.2	1,918
November	15	892	30	1,785	29.9	1,779
December	15	922	30	1,844	24.1	1,481
Total		17,949		27,052		34,983

1/ Low level of aquatic habitat potential.

2/ High level of aquatic habitat potential

3/ Includes a flow of 202 cfs for 24 hours.

1. STREAM

Missouri River between Holter Dam and the mouth of the Smith River.

2. GENERAL DESCRIPTION

This reach of the Missouri River is located between Holter Dam and the mouth of the Smith River (T14N, R3W, Sec. 5 to T19N, R2E, Sec. 9). The length of this reach is 63 miles (101 kilometers) and has an average width of about 400 feet. The average gradient is 3 ft per mile with the most common substrate type being sand and gravel.

Major tributaries entering the Missouri River in this reach include Sheep Creek, Dearborn River, Stickney Creek and Little Prickly Pear Creek (Figure 39). These streams add considerable flow to the Missouri during spring runoff but late summer and winter flow is largely insignificant to the river system.

This reach of river flows through two distinct geologic zones. From Holter Dam to Sheep Creek, a distance of about 25 miles, the river flows through a mountain canyon having an average width of about 3000 ft. A narrow band of riparian vegetation consisting primarily of willow and some cottonwood generally line the riverbanks. Several brushy islands are periodically found in this area. Below the confluence of Sheep Creek, the river abruptly leaves the mountain area and meanders through a wide and generally flat prairie zone. Several old oxbows have created shallow sloughs and backwater areas. Extensive growths of riparian vegetation consisting of a willow/cottonwood overstory accompanies the river floodplain through most of this area. Several brushy islands are also found throughout this portion of the river.

Flow in this reach of the Missouri River is largely controlled from Canyon Ferry Reservoir, the largest of three consecutive upstream reservoirs. Canyon Ferry Dam was completed in 1953 by the Bureau of Reclamation for irrigation, power, flood control and recreation. Canyon Ferry has a full surface area of 35,200 acres and a storage capacity of 2,051,000 acre feet. Hauser and Holter Reservoirs lie downstream of Canyon Ferry Dam and provide storage head for power generation. They are owned and operated by Montana Power Company.

Fishery

This reach of the Missouri River supports substantial cold water fish populations and provides an excellent recreational fishery. Mountain whitefish, rainbow trout and brown trout are the most

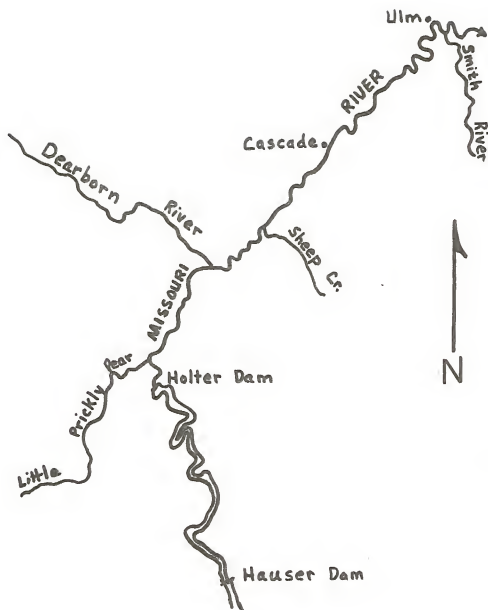


Figure 39. Map of Missouri River and tributaries between Holter Dam and confluence of Smith River.

common sport fish. Many trophy trout from 5 to 10 pounds are taken from this reach each year. Mountain whitefish are very abundant and comprise an important winter fishery. A summary of catch statistics from anglers reporting their fishing trips through the Department of Fish and Game fisherman log program reveals excellent success. In 1976, 301 angler days yielded 875 rainbow trout, 113 brown trout and 515 mountain whitefish while in 1977, 299 angler days reported 831 rainbow trout, 180 brown trout and 1,085 mountain whitefish. Other fish species reported taken included brook trout, cutthroat trout, walleye, yellow perch, bullhead, burbot, longnose sucker, white sucker and carp.

An estimate of total fishing pressure on Montana waters was conducted for the 1975-76 fishing season. The survey revealed about 69,500 angler days were expended on this 63 mile reach of river.

Access to the river is good throughout this reach. There are several public access areas along the upper half of this reach. Old U.S. Highway 91 now designated as a recreation road parallels considerable portions of the river and also provides easy access. River flow is always good for floating and many recreationists take advantage of this sport. The outstanding scenery and fishing add to the enjoyment of this activity.

Waterfowl

Many species of waterfowl are seasonally associated with this reach of river. Mallards, mergansers, Canadian geese and teal nest along the river on islands, backwater areas and sloughs. Some mallards, goldeneyes and geese spend the winter along ice-free areas of the river. During spring migration, the river is often an important resting area for thousands of pintails, mallards and other waterfowl enroute to northern nesting areas. Several species of shore birds such as killdeer, snipe, phalarope and gulls are also seasonally associated with the river.

Wildlife

The extensive riparian vegetation along the lower half of this reach provides excellent habitat for many important wildlife species. Large numbers of white-tailed deer, mule deer and ring-necked pheasant are found the year round. Small patches of riparian vegetation along the river in the mountain canyon area also provide habitat for a few deer. Mink, muskrat, beaver, raccoon and a few river otter are found throughout this reach. Bald eagles are often observed along the river corridor during the winter.

Environmental Concerns

Aquatic habitat conditions are generally good throughout most of this reach. In the canyon reach, from Holter Dam to Sheep Creek, the banks are stable and flows have been good except in dry years. Sedimentation is not a problem in the upper portion of this reach, however, the Dearborn River adds considerable sediment

during spring runoff. A few minor tributaries near the lower end of the river reach also add considerable sediment during runoff. High eroding riverbanks in a few areas between the towns of Cascade and Ulm also contribute considerable sediment to the river system.

Development of road systems have encroached on the river channel in the canyon area. Riparian vegetation was destroyed in these areas and recovery has been very slow.

Subdivision development poses a potential threat to water quality. Many homes have been built on the banks of the Missouri River between the town of Cascade to near the confluence of the Dearborn River. Some of these homes are periodically affected by flood water caused from ice jams.

As mentioned previously, river flow is regulated by three upstream reservoirs. The largest reservoir, Canyon Ferry, influences seasonal flow since it is operated for flood control in the spring and for power and irrigation maintenance the remainder of the year. Releases from Holter Reservoir had daily impact on river flow and aquatic resources until 1971. Late summer and fall daily flows generally fluctuated from about 1,000 cfs to 7,000 cfs. Power peaking operations were changed at Holter Dam to accommodate steady releases. Depending on the water year, late summer and fall flows have generally been steady in the 4,000 to 5,000 cfs range since 1971.

Method Used For Flow Recommendations

Photo points and observations were made of the river habitat at various flows. Montana Power cooperated by releasing controlled flows of 3,000 cfs, 2,000 cfs and 1,000 cfs from Holter Dam (Hill 1973). Results of this experiment revealed many river islands lost integrity at 3,000 cfs and below. In many areas water receded from shoreline vegetation which seriously reduced cover for fish. Mid-channel gravel bars gradually became exposed at flows of 3,000 cfs and often became barren, isolated islands at lesser flows. Aquatic invertebrate habitat became seriously affected as flows receded below 3,000 cfs. Figures 40, 41 and 42 depict aquatic habitat degradation at one point on the river.

Flow Recommendations

In 1970, the Montana Department of Fish and Game filed a flow reservation of 3,000 cfs in the Missouri River from Holter Dam downstream to the mouth of the Smith River under Chapter 345, Section 89-801, R.C.M. 1947 (Murphy's Law). Even though a flow of 3,000 cfs exposed some gravel bars and islands in this reach of the Missouri, it was felt this flow could sustain substantial aquatic life over a period of time.

A hydrograph depicting flows from USGS gaging stations below Holter Dam and near Ulm is presented in Figure 43. Mean monthly flows measured in 1972, a near normal flow in recent years, and flows from 1977, an extremely low flow year, are compared for the two stations. Discharge is generally higher at the Ulm



Figure 40. Missouri River at 3,000 cfs. Note midstream gravel bars beginning to show and water slightly drawn away from shoreline.



Figure 41. Missouri River at 2,000 cfs. Note extensive exposure of river bed and withdrawal of water from shoreline vegetation.

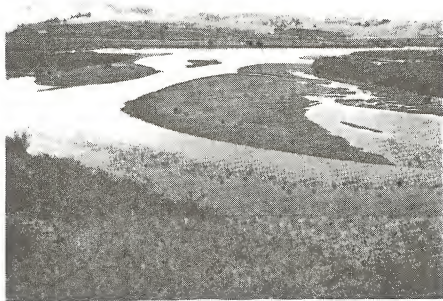


Figure 42. Missouri River at 1,000 cfs. Island at right side of photo is isolated. Water velocity is extremely low at mid-channel.

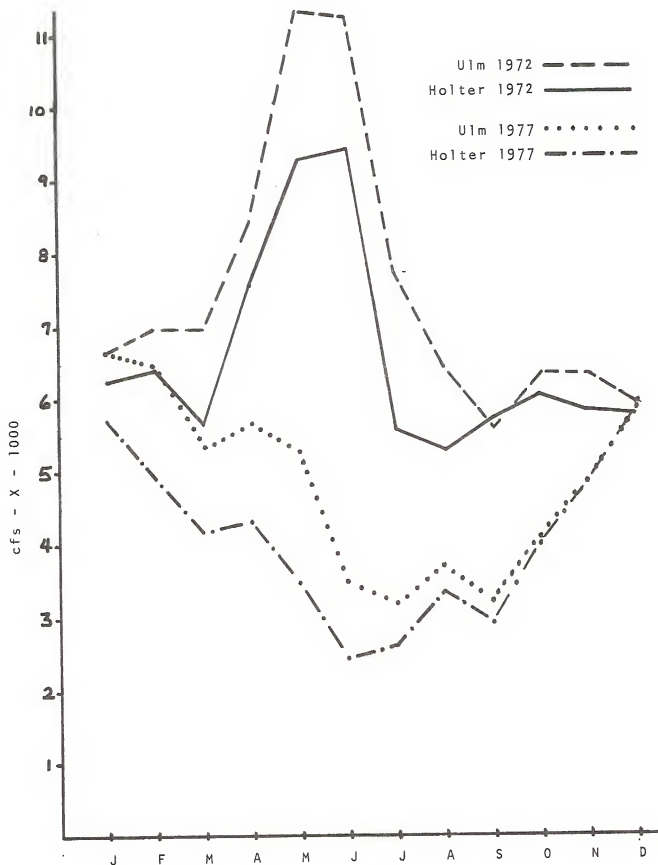


Figure 43. Mean monthly discharge of the Missouri River below Holter Dam and near Ulm in 1972 and 1977.

station, however, this station lies downstream from the mouth of the Smith River. Observations reveal that tributaries upstream from the Smith River usually add more water to the Missouri than what is diverted or pumped by water users. Accretion to the Missouri River by the Smith River is usually less than 200 cfs by late summer. Dewatering by diversion within this river reach has not been a problem for maintaining aquatic life.

On a normal water year, excellent aquatic habitat maintenance flow is found in this reach of the Missouri River. Even on a low water year, such as in 1977, a minimum flow of at least 3,000 cfs can be maintained in the river with proper water management from Canyon Ferry Reservoir. A recommended minimum flow of 3,000 cfs or 2,171,900 acre feet per year, will provide a low level of aquatic habitat potential, although flushing flows exceeding 10,000 cfs will be needed almost every year to maintain the character of the river channel.

1. STREAM

Little Prickly Pear Creek

2. GENERAL DESCRIPTION

Little Prickly Pear Creek rises on the east slope of the Continental Divide in Lewis and Clark County approximately 30 miles northwest of Helena. It flows northwesterly for 35 miles to its confluence with the Missouri River about 2 miles downstream from Holter Dam (Figure 44). The stream flows through several distinct topographic zones, including mountain headwater, meadow and canyon areas. The creek drains an area approximately 394 square miles, mostly of grassland with open stands of ponderosa pine. The average gradient of Little Prickly Pear Creek is about 33 feet per mile. Stream width varies from 5 to 10 feet in the headwater area to about 45 feet near the mouth. Substrate varies from sand to pebble in the meadow zones and from pebble to cobble in the canyon zones.

A county road generally parallels Little Prickly Pear Creek from near the headwaters to the Sieben Ranch and Interstate Highway 15 lies adjacent to the stream from the ranch to the town of Wolf Creek.

Land use along Little Prickly Pear Creek is predominantly cattle ranching. Hay meadows have been developed along a considerable portion of the stream in the meadow zones.

3. REACH #1

From confluence of Clark Creek to Missouri River.
(T13N, R4W, Sec. 9 to T15N, R3W, Sec. 29)

Description

This reach of Little Prickly Pear Creek is 15 miles long and has an average width of about 45 feet. The stream flows through a narrow mountain canyon paralleled by a railroad, an interstate highway and a frontage recreation road. The streambanks have sparse vegetative cover since over 80 percent of the stream was altered for interstate highway construction (Elser 1968). In areas that have not been altered, dense clumps of cottonwood and willow are found in close association with the streambanks. Altered streambanks have been armored with large rock riprap. Rock deflectors were installed in many of the altered segments of this reach and pools have developed below them.

Major tributaries to this reach of Little Prickly Pear Creek include Lyons, Sheep, Little and Wolf creeks (Figure 44).

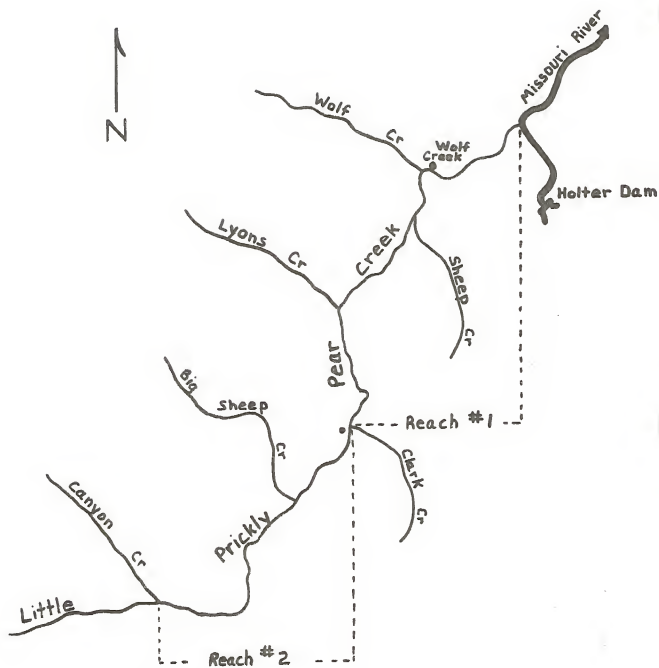


Figure 44. Map of Little Prickly Pear Creek and major tributaries

The lower portions of Sheep and Little creeks usually go dry every year. The total drainage area to the lower end of this reach is 386 square miles.

Fishery

Little Prickly Pear Creek supports cold water fish populations and provides a local important recreational fishery. Rainbow trout, brown trout, brook trout and mountain whitefish are the sport fish found in the stream. Trout population estimates made in 1969 revealed 405 yearling and older fish per acre of stream with a standing crop of 113 pounds per acre. Rainbow trout predominated, comprising 340 fish and 66 pounds per acre with brown trout comprising 65 fish and 47 pounds per acre. Only a few mountain whitefish and brook trout were taken.

All trout are naturally reared in Little Prickly Pear Creek. The stream has not been stocked with hatchery fish since 1954. Some rainbow and brown trout from the Missouri River run into the lower portion of this reach to spawn. Longnose and white suckers also run into Little Prickly Pear during the spawning season.

Access to this reach of stream is excellent. Upon completion of Interstate Highway 15, old U.S. Highway 91 was converted into a recreation road and several picnic and parking areas were developed along it. Data from the 1975 statewide fishing pressure estimates indicate nearly 3,800 angler days were expended on Little Prickly Pear Creek. Observations reveal most fishing pressure occurs on this reach of the stream.

Waterfowl

Occasional pairs of mallards and mergansers nest along this reach of stream. At times large numbers of mallards are found on the stream during cold periods in the fall.

Wildlife

Because the stream is mostly sandwiched between highways and a railroad for most of this reach, use of the streambottom is very limited for large game animals. Mink, beaver and raccoons frequent the streambottom year-round. Various species of song-birds are seasonally found frequenting the riparian zone.

Environmental Concerns

Aquatic habitat has been permanently altered by interstate highway and railroad construction along most of this reach. Elser (1968) stated about 87 percent of the stream channel from Lyons Creek to Wolf Creek had been altered by highway construction. Fish habitat has been enhanced by placement of rock deflectors that were installed throughout most of the heavily altered stream sections. Woody vegetation (mostly willow) presently provide bank cover for trout in several

areas that were completely denuded. However, many areas were so heavily armored with riprap that riparian vegetation may never restore to near natural conditions.

Sedimentation is not a problem in this reach although the flow is quite turbid during spring runoff. The stream usually has a good flow of water except during extremely dry years. Flows were recorded near the town of Wolf Creek by the USGS from May 1962 through September of 1967. Average winter flow appears adequate for maintaining aquatic life. Water is diverted for irrigation of about 200 acres of land near the lower end of this reach. In extremely dry years, these diversions have totally dewatered the lower 2 miles of this reach.

Method Used For Flow Recommendations

The wetted perimeter method was used to identify the high and low level of aquatic habitat potential (see page 7 for detailed explanation) for the months of July through April. Five cross-sections were surveyed near the lower end of the study reach in T14N, R4W, Sec. 2. The wetted perimeter projections at various flows were generated by the IFG4 Hydraulic Simulation Program (see page 7).

Since flow data was only collected for 6 years by the USGS, no duration hydrograph and flood-frequency data is available for this stream. Therefore, dominant discharge/channel morphology was assumed from the median value of the averages of the May and June discharges for the 6 year period.

Flow Recommendations

The relationship between wetted perimeter and discharge for a composite of five cross-sections of Little Prickly Pear Creek is shown in Figure 45. The two inflection points identified in the figure occur at flows of 25 and 100 cfs and correspond to the low and high levels of aquatic habitat potential, respectively (page 7).

The bankfull discharge for this reach of Little Prickly Pear Creek cannot be calculated because of the lack of flow data. Therefore, recommendation for a 24 hour peak flow is not made at this time. An estimated 70 percent exceedance flow of 360 cfs is recommended from May 16 to June 15. To simulate a natural rise and fall of high water conditions, a flow of 250 cfs is recommended from May 1 to 15 and June 16 to 30.

Instream flows which will maintain a low and high level of aquatic habitat potential are identified and compared to the mean monthly flows in Table 28. Instream flows selected for this reach of Little Prickly Pear Creek correspond to the high level of aquatic habitat potential. For all months except April, May, June and July, the recommended instream flows exceed the mean monthly flows. This indicates that any additional water withdrawals

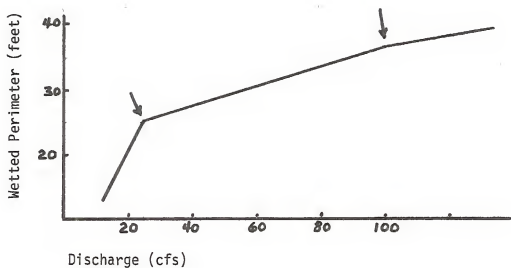


Figure 45. Wetted perimeter versus discharges for five cross sections on Reach #1 on Little Prickly Pear Creek

Table 28. Instream flows representing low and high level of aquatic habitat potential compared to mean monthly flows in reach #2 of Little Prickly Pear Creek.

Time Period	Low		Flow High		Mean	
	CFS	AF	CFS	AF	CFS	AF
January	20	1,230	50	3,074	35	2,152
February	20	1,111	50	2,777	43	2,388
March	20	1,230	50	3,074	40	2,460
April	20	1,190	50	2,975	86	5,117
May	165 ^{1/}	10,145	165 ^{1/}	10,145	198	12,175
June	165 ^{2/}	9,818	165 ^{2/}	9,818	169	10,056
July	20	1,230	50	3,074	52	3,197
August	20	1,230	50	3,074	27	1,660
September	20	1,190	50	2,975	44	2,618
October	20	1,230	50	3,074	39	2,398
November	20	1,190	50	2,975	38	2,261
December	20	<u>1,230</u>	50	<u>3,074</u>	39	<u>2,398</u>
		32,024		50,109		48,880

^{1/} Average of 136 cfs from May 1 to 15 and 194 cfs from May 16 to 31.

^{2/} Average of 194 cfs from June 1 to 15 and 136 cfs from June 16 to 30.

during the months of August through March could endanger the aquatic resource. Since this reach of stream lies in a popular recreation area and has excellent public access, it is imperative that the existing flows are preserved.

4. REACH #2

From confluence of Canyon Creek to confluence of Clark Creek.
(T12N, R5W, Sec. 8 to T13N, R4W, Sec. 9)

Description

This reach of Little Prickly Pear Creek is 12.7 miles long and has an average width of about 24 feet. The stream flows through a wide meadow zone for about 5 miles before entering a narrow mountain canyon zone for another 6 miles. The lower end of this reach flows through a short mountain meadow zone. A graveled county road and a railroad generally parallel most of this reach.

Riparian vegetation mostly consists of willow interspersed with alder, red dogwood and occasional clumps of cottonwood. This is found in a generous band along the stream through the meadow zones to a narrow dense band through the mountain canyon zone except where railroad construction in 1887 altered about one-third of the stream channel. This construction greatly reduced vegetative cover on the streambanks. Land use along this reach is primarily agricultural consisting of hay production and cattle grazing.

Major tributaries to this reach of Little Prickly Pear Creek are Canyon Creek and Big Sheep Creek (Figure 44). Several other small tributaries are present but these generally go dry by mid-summer. The total drainage area to this reach of stream is 270 square miles.

Fishery

This reach of stream also supports a cold water fishery. Standing crops of trout vary from 40 to 226 pounds per acre (Elser 1968) depending on various areas of the stream. Brown trout are the most abundant salmonid species in this reach, comprising about 52 percent of the population followed by rainbow trout (36%), brook trout (10%) and mountain whitefish (2%). Longnose and white suckers are abundant in the slower portions of the stream, primarily in the meadow zones.

This entire reach of stream flows through private land. However, several areas of the stream are accessible and open to public fishing. There are no developed campgrounds or picnic areas along this reach, although off-road parking is allowed in several areas. This reach is moderately popular for local fishermen but does not receive the angling pressure of reach #1.

Wildlife

Several white-tailed and mule deer occupy the brushy bottomland

along this reach. Beaver, raccoon and mink are associated with the streambottom throughout the year. A few ruffed grouse, grey partridge and a variety of songbirds are seasonally found inhabiting the riparian zone.

Waterfowl

A few mallards are occasionally found frequenting this reach of stream.

Environmental Concerns

Man caused channel alterations affect over one-third of this reach in the mountain zone. Stream habitat in those portions of the creek that were rechanneled for railroad construction in 1887 still have not recovered to support trout populations comparable to those found in natural portions of streams. Intensive agricultural use has denuded riparian vegetation adjacent to portions of the stream. Streambank erosion is excessive in some of these areas.

The water in Little Prickly Pear Creek is heavily used for irrigation. At times, irrigation withdrawals reduce stream flow to levels detrimental to aquatic life.

A considerable area of land has been subdivided along streams in the Canyon Creek drainage and near the upper portion of this stream reach. Development of these subdivisions pose a potential threat to water quality and riparian vegetation.

Sedimentation is seldom a problem to aquatic life through this reach although tributaries often contribute considerable amounts during spring runoff. Logging practices on private land in the upper watershed pose as a potential contributor to increased sediment loads.

Method Used For Flow Recommendations

The wetted perimeter method described under Reach #1 was used to identify the high and low level of aquatic habitat potential for the months of July through April. Five cross-sections were surveyed near the center of this reach in T12N, R5W, Sec. 11.

Flow data was only collected over a 6 year period (1962 through 1967) by the USGS near the Sieben Ranch at the lower end of this reach. Because of this short period of flow records, no duration hydrograph and flood frequency data is available for this reach of stream. The dominant discharge/channel morphology was assumed from the median value of the averages for the May and June discharges over the 6 year period.

Flow Recommendations

The relationship between wetted perimeter and discharge for a composite of five cross-sections of this reach is shown in Figure 46. The two inflection points identified in the figure

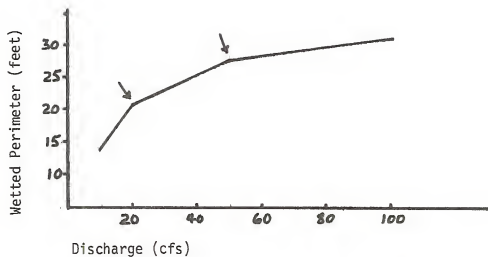


Figure 46. Wetted perimeter versus discharges for 5 cross sections on Reach #2 on Little Prickly Pear Creek

occur at flows of 20 and 50 cfs and correspond to the low and high levels of aquatic habitat potential, respectively (page 7).

The bankfull discharge for this reach of Little Prickly Pear Creek cannot be calculated because of the lack of flow data. Therefore, recommendations for a 24-hour flood flow is not made at this time. An estimated 70 percent exceedance flow of 194 cfs is recommended from May 16 to June 15. To simulate a natural rise and fall of high water conditions, a flow of 136 cfs is recommended from May 1 to 15 and from June 16 to 30.

Instream flows which will maintain a low and high level of aquatic habitat potential are identified and compared to the mean monthly flows in Table 29. The instream flows recommended for reach #2 of Little Prickly Pear Creek correspond to the high level of aquatic habitat potential. For all months except May, June and July, the recommended flows exceed the mean monthly flows. The low mean monthly flow for August is the result of irrigation withdrawals above the USGS gage station. Any additional water withdrawals during the months of August through April could endanger the wild trout fishery presently provided in this reach.

Table 29. Instream flows representing low and high level of aquatic habitat potential compared to mean monthly flows in reach #1 of Little Prickly Pear Creek.

Time Period	Low		Flow High		Mean	
	CFS	AF	CFS	AF	CFS	AF
January	25	1,537	100	6,149	51	3,136
February	25	1,388	100	5,554	71	3,943
March	25	1,537	100	6,149	63	3,874
April	25	1,488	100	5,950	175	10,413
May	305 ^{1/}	18,863	305 ^{1/}	18,863	387	23,796
June	305 ^{2/}	18,149	305 ^{2/}	18,149	339	20,172
July	25	1,537	100	6,149	111	6,825
August	25	1,537	100	6,149	58	3,566
September	25	1,488	100	5,950	69	4,106
October	25	1,537	100	6,149	67	4,120
November	25	1,488	100	5,950	64	3,808
December	25	<u>1,537</u>	100	<u>6,149</u>	58	<u>3,566</u>
		52,086		97,310		91,325
<hr/>						
^{1/}	Average of 250 cfs from May 1 to 15 and 360 cfs from May 16 to 31.					
^{2/}	Average of 360 cfs from June 1 to 15 and 250 cfs from June 16 to 30.					
<hr/>						

1. SPRING CREEK

Big Spring Creek

2. GENERAL DESCRIPTION

Big Spring Creek is one of the largest spring-fed streams located in Montana. The majority of the flow comes from a large spring located near the Montana Department of Fish and Game's largest trout hatchery. USGS records show this flow to be very stable, averaging 107 cfs for the period of record, 1932-1957. The City of Lewistown, with a population of about 9,000, diverts water for municipal use above the gage locations. Tributaries which contribute additional flow below this point include East Fork, Pike, Big and Little Casino, Boyd and Cottonwood creeks. (Figure 47). These tributaries drain the north slopes of the Big Snowy Mountains and the southwest corner of the Judith Mountains.

Big Spring Creek is considered by fishermen to be the most important trout stream in central Montana and has produced many fish over 10 pounds and several between 18 and 20 pounds. In addition to the state hatchery, three privately owned hatcheries use the high quality water to raise trout for commercial purposes.

3. REACH #1

From state fish hatchery to the mouth of Cottonwood Creek (T14N,R19E, Sec. 5 to T16N,R17E,Sec. 28).

Reach #1 is 24 miles long and has an average width of approximately 43 feet. The average gradient is about 20.5 feet per stream mile and the floodplain averages about 1150 feet in width. The stream substrate composition ranges from sand to rubble.

Banks are relatively stable with water birch, willows and hawthorne being the dominant bank vegetation. The bottomland is used primarily for hay production and grazing. In the 9 miles upstream from the City of Lewistown, permanent homes exist along the stream in several areas.

Because of the importance of the stream, a considerable amount of biological data has been collected on fish populations and invertebrate organisms (Marcoux 1969, Poore 1975, 1976, 1977, 1978). Both rainbow and brown trout inhabit the stream. In the upper portion of reach #1, brown trout make up about 10% of the trout population but this ratio changes downstream to 49% brown trout in the lowest section where we have population estimates. The following table gives a breakdown of mark-recapture trout population estimates made in 1977 in section D with one of the highest trout populations and section B with one of the lowest trout populations (Table 30).

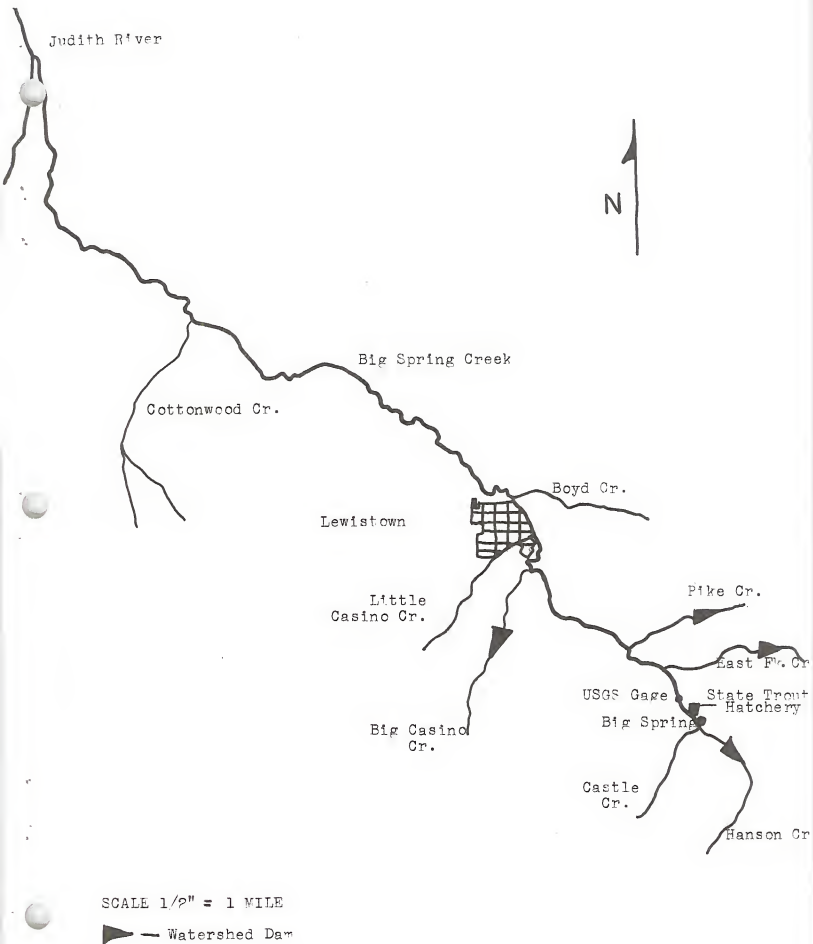


Figure 47. Map of Big Spring Creek.

Table 30. 1977 estimates for fish over 5 inches in total length.

	Length	Area (Acres)	No. Rainbow (Pounds)	No. Brown (Pounds)	Total Weight	Pounds/ Acre
Sec. B	5843 ft	5.82	702 (297)	82 (110)	407	70
Sec. D	4394 ft	4.58	1949 (698)	393 (287)	985	215

In addition to rainbow and brown trout, other game fish present in limited numbers include mountain whitefish and brook trout. Other species, in order of decreasing abundance, include mottled sculpin, longnose dace, longnose sucker, white sucker, mountain sucker, northern redbhorse, carp and lake chub.

During 1968 and 1969 an intensive fishing pressure study was conducted on the upper 9 miles of Big Spring Creek (Peterson 1970). Total fishermen days per stream mile was 635 in 1968 and 534 in 1969. In 1968 11,986 game fish were caught during 5,077 fishermen days and in 1969 7,774 game fish were caught during 4,109 fishermen days.

Although the majority of fishermen use takes place from the bank, a limited amount of floating use does occur. Most floating activity, however, is related to swimming, canoeing, duck hunting, bird watching, and taking advantage of the scenery.

Riparian vegetation along the stream and adjacent foothill country is used by large numbers of white-tailed deer and pheasants. Furbearers using the area include mink, muskrat and beaver. Waterfowl, particularly wintering mallards, make considerable use of the stream. The open water throughout the winter which attracts duck concentrations also attracts bald eagles to the watershed area.

Because of a history of flash flooding, flood control dams have been constructed over the past 10 years on the four major tributaries located upstream from Lewistown. These dams have altered the natural flows during flooding from flash floods of short duration to bankfull flows for 4 to 6 weeks as the dams drain down. These extended high flows have significantly increased erosion rates within the watershed.

Several channel alterations on the outskirts of Lewistown have caused extensive erosion and resulted in the expenditure of approximately \$750,000 for stream stabilization projects. Two irrigation ditches divert water from the stream near Lewistown and several pump systems divert additional water for irrigation. A primary sewage treatment plant discharges 4-7 cfs of effluent into the stream.

In 1970 water in Big Spring Creek was filed for under Section 89-801, R.C.M. 1947. The 1970 filing was for 120 cfs in reach #1 and 150 cfs in reach #2 year-round. To maintain the high level of aquatic habitat potential, the recommended instream flow is based on the department's 1970 filing. For reach #1, the recommended flow is 120 cfs from January 1 through December 31. Existing data does not allow flows to be determined to maintain the low level of aquatic habitat potential for this reach.

4. REACH #2

From the mouth of Cottonwood Creek to the confluence of Big Spring Creek and the Judith River
(T16N,R17E,Sec.28 to T17N,R16E, Sec.26).

The 11 miles of stream in reach #2 is more unstable with more eroded banks and greater sediment deposition than in reach #1. Channel width averages about 50 feet and flows are somewhat greater than in reach #1. Substrate type ranges from sand to cobble. The floodplain is little used for agriculture and only one farm is located along the stream. Dense stands of cottonwoods, willows, water birch, and hawthorne cover much of the bottomland.

Little detailed information exists on fish populations within this reach. Good trout populations are found through the area with brown trout probably outnumbering rainbow trout. Two additional fish species are found in this reach, goldeye and sauger. Sauger move into the lower reach from the Judith River, probably to spawn. Other fish species, wildlife species and waterfowl are similar to those discussed for reach #1. Fishing pressure and recreational use is considerably lower in reach #2 than in reach #1.

To maintain the high level of aquatic habitat potential, the recommended instream flow is based on the department's 1970 filing. For reach #2, the recommended flow is 150 cfs from January 1 through December 31. Existing data does not allow flows to be determined to maintain the low level of aquatic habitat potential for this reach.

1. STREAM

Belt Creek

2. GENERAL DESCRIPTION

The headwaters of Belt Creek arise in the heart of the Little Belt Mountains north of Kings Hill. Belt Creek flows in a northerly course for nearly 81 miles before its confluence with the Missouri River 2 miles downstream of Morony Dam (Figure 48).

The upper 33 miles of Belt Creek flows through a V-shaped mountain canyon before emerging into a relatively narrow foothills valley. Major tributaries to Belt Creek include Jefferson, Dry Fork, Tillinghast, Pilgrim, Logging, Otter and Little Belt creeks.

The mean flow of Belt Creek for a 25-year period of record at the USGS gage near Monarch is 189 cfs. Flows ranged from 0 - 11,000 cfs. The high water period occurs from May through June.

The mountain canyon area of Belt Creek has a high scenic value. It is a popular recreation area for fishing, hunting, picnicking, camping and hiking. Many summer homes are located along the stream in the Monarch-Neihart area. Cattle ranching predominates land use along Belt Creek in the foothills zone.

Belt Creek is paralleled by paved highways over most of its length, those being U.S. 89 and FAS 331. The communities of Belt, Neihart and Monarch are located along the course of the stream.

3. REACH #1

From the mouth of Dry Fork Belt Creek at Monarch to the mouth of Big Willow Creek.
(T15N, R7E, Sec. 3 to T20N, R7E, Sec. 7)

Description

The reach of Belt Creek from the Dry Fork to the mouth of Big Willow Creek is 42 miles long and has an average width of about 45 feet. The upper 15 miles of this reach flows through a timbered mountain canyon; the stream is mostly entrenched in a rugged gorge lined with limestone cliffs. The gradient

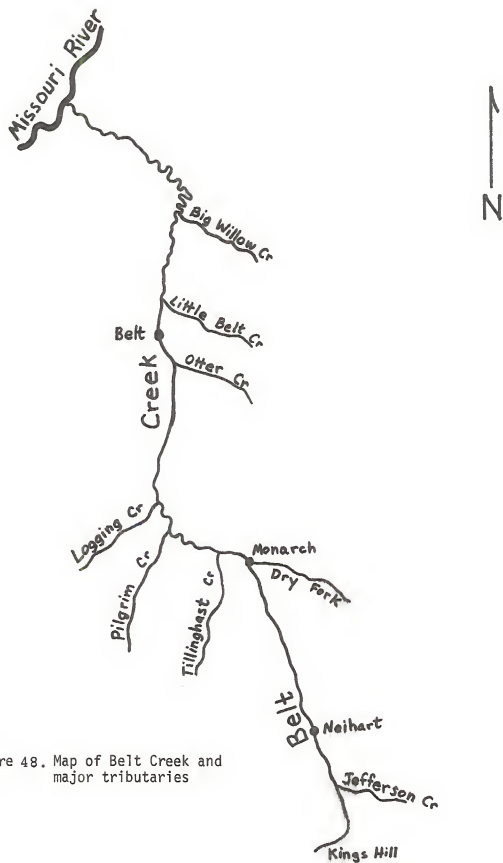


Figure 48. Map of Belt Creek and major tributaries

here is 39 feet per mile with the substrate type mainly pebble and cobble. The lower 27 miles of the reach flows through a foothill zone in a relatively narrow valley. The gradient is 24 feet per mile with the most common substrate type again being pebble and cobble.

Woody riparian vegetation associated with Belt Creek consist primarily of willow, cottonwood, chokecherry and rose. This bottomland is scattered within the canyon area to a continuous band varying from several feet to over a quarter mile wide in the foothill zone.

Fishery

Belt Creek in this reach supports cold water fish populations and provides a local important recreational fishery. Rainbow trout, brown trout and mountain whitefish are the most common game fish. Rainbow trout comprise about 80 percent of the trout population.

Trout populations in this reach of Belt Creek are comprised mainly of small fish. Natural trout populations are somewhat depressed in the lower 27 miles because of habitat deterioration which will be discussed later. Consequently, this portion of Belt Creek receives a supplementary plant of 5,000 catchable trout yearly. Larger and more trout are found in the upper 15 miles of the study reach in the mountain canyon area. Here the stream channel is stable and contains many deep, well developed pools.

During high spring flow, several fish species from the Missouri River run up Belt Creek to spawn. These include sauger, goldeye, northern redhorse sucker and occasional large rainbow trout. Spawning runs have been documented upstream as far as Otter Creek.

Much of Belt Creek is accessible and open to public fishing. Considerable public land lies adjacent to the upper 15 miles of the reach. Information collected from the statewide fishing pressure estimate for the license year 1975-76 reveals nearly 12,500 angler days were expended on Belt Creek. It is not known what portion of this pressure was expended in the study area, but field observations indicate the majority of the anglers use this reach of stream.

Waterfowl

The swift waters of Belt Creek are not conducive to waterfowl. A few mallards, teal and mergansers nest in old oxbows and slough areas along the stream.

Wildlife

Wildlife commonly associated with the riparian zone include mule and white-tailed deer, ringnecked pheasant, raccoon, mink,

beaver and a variety of songbirds.

Environmental Concerns

Aquatic habitat conditions are somewhat unstable in Belt Creek. Over 21 miles or 26% of the entire stream has been altered for highway and railroad construction, agricultural, urban and industrial development (Department of Fish and Game files). Nearly one-third of the channel has been altered in the lower 27 miles in the study area. While severe alterations have been tempered in recent years, the stream is still attempting to readjust through erosion of banks and scouring of the stream bottom.

Past mining activity in the Belt Creek drainage has created acid seeps high in toxic metals. Hard rock metal mining has caused water quality problems in Carpenter Creek and the Dry Fork of Belt Creek in the Monarch-Neihart area. Drainage from these streams has somewhat impaired water quality in Belt Creek (Braico and Botz 1974). Old coal mines near the town of Belt also contribute some acid mine water to Belt Creek. Belt Creek has moderately hard, calcium bicarbonate water, which buffers most of the acid seep pollution.

Sedimentation is seldom a problem throughout most of this reach. During spring runoff, tributary streams often contribute considerable amounts, especially Otter Creek. Turbid flow from Otter Creek often occurs long after the remainder of the tributaries have cleared.

Belt Creek frequently goes dry from bank seepage above the mouth of Otter Creek. Irrigation diversion has little influence to the natural flow pattern of Belt Creek. Less than 50 acres of land are irrigated from this stream.

Method Used For Flow Recommendations

The wetted perimeter method was used to identify the high and low level of aquatic habitat potential (see page 7 for detailed explanation) for the months of July through April. Five cross-sections were surveyed near the lower end of the study reach in T20N, R8E, Sec. 13. The wetted perimeter projections at various flows were generated by the IFG4 Hydraulic Simulation Program (see page 7).

The data needed to derive flow recommendations for the high water period (May 1 - June 30) are unavailable due to the lack of USGS gage records for lower Belt Creek. Future flow recommendations during this period will be based on the dominant discharge/channel morphology concept (see page 5).

Flow Recommendations

The relationship between wetted perimeter and discharge for a composite of five cross sections of Belt Creek is shown in Figure 49. The two inflection points identified in the figure occur at flows of 55 and 85 cfs and correspond to the low and

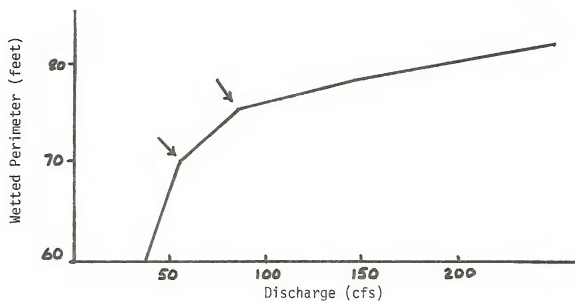


Figure 49. Wetted perimeter versus discharges for five cross-sections on Belt Creek.

high levels of aquatic habitat potential, respectively (see page 7).

The bankfull flow for reach #1, presently undetermined, should be established for 24 hours during June. During the remainder of the high water period (May 1 - June 30), the 70% exceedance flows, presently undetermined, are recommended.

The instream flows that will maintain a low and high level of aquatic habitat potential in reach #1 of Belt Creek are partially identified in Table 31. Instream flows recommended for reach #1 of Belt Creek correspond to the low level of aquatic habitat potential. The winter flows for the months of November, December, January, February and March are generally below the recommended low maintenance flow. This is undoubtedly due to the wide, flat channel profile of Belt Creek which has developed from abnormally high spring runoff and from the influence of many man caused stream alterations. The low winter flows in Belt Creek are undoubtedly causing adverse effects on the sport fish populations; therefore it is imperative that natural winter flow is maintained in the stream. High spring flows are needed not only for cleansing gravel and carrying bedload but for diluting mine seeps which produce a greater volume of dissolved toxic metals at this time of year.

Table 31. Instream flows representing low and high levels of aquatic habitat potential for reach #1 of Belt Creek.

Time Period	Low ^{1/}		High ^{2/}	
	CFS	AF	CFS	AF
January	55	3,382	85	5,257
February	55	3,055	85	4,720
March	55	3,382	85	5,257
April	55	3,273	85	5,088
May	3/		3/	
June	3/		3/	
July	55	3,382	85	5,257
August	55	3,382	85	5,257
September	55	3,273	85	5,080
October	55	3,382	85	5,257
November	55	3,273	85	5,088
December	55	3,382	85	5,257

1/ Low level of aquatic habitat potential.

2/ High level of aquatic habitat potential.

3/ Flows presently unidentified.

1. RIVER

Smith River

2. GENERAL DESCRIPTION

The Smith River drainage lies in westcentral Montana, almost due south of Great Falls (Figure 50), between the Big Belt Mountains on the west and the Little Belt and Castle Mountains on the east. The drainage is approximately 75 miles in length and the width varies from 3 to 45 miles. The total area is slightly over 2,000 square miles. The elevation of the floor of the drainage varies from 3,350 to 5,400 feet above sea level. The highest mountain peaks range from 8,500 to 9,500 feet above sea level.

The Smith River is formed by the junction of the North and South Forks of the Smith River about 4 miles southwest of the town of White Sulphur Springs. The North Fork drains part of the southwest slopes of the Little Belt Mountains and the northwest slopes of the Castle Mountains. The South Fork originates along the southwest flank of the Castle Mountains and from the bench lands between the Castle and Big Belt Mountains. The main stem of the Smith River then flows northwesterly through a narrow valley until it enters a deep mountain canyon about 10 miles north of Fort Logan. After emerging from the canyon, the river meanders through a relatively narrow valley flanked by rolling grasslands until it joins the Missouri River near the town of Ulm.

Numerous tributaries originate in the Big Belt and Little Belt Mountains to join the Smith River. Some of the major tributaries originating in the Big Belt Mountains are Birch, Camas, Beaver, Rock and Hound creeks. Those from the Little Belt Mountains are Newlan, Sheep, Eagle, Tenderfoot and Deep creeks.

Approximately 2,500 people reside within the Smith River drainage. A major highway system makes the area accessible to the surrounding urban areas which have a population of over 150,000 people.

In the early 1860's the discovery of gold in the surrounding mountains stimulated a heavy influx of miners. As gold was depleted and mining operations abandoned, farming and ranching began to take over as the predominant economy, and they remain so today.

The mean discharge of the Smith River for an 18-year period of record at the USGS gage near Eden (river mile 26) was 338 cfs.

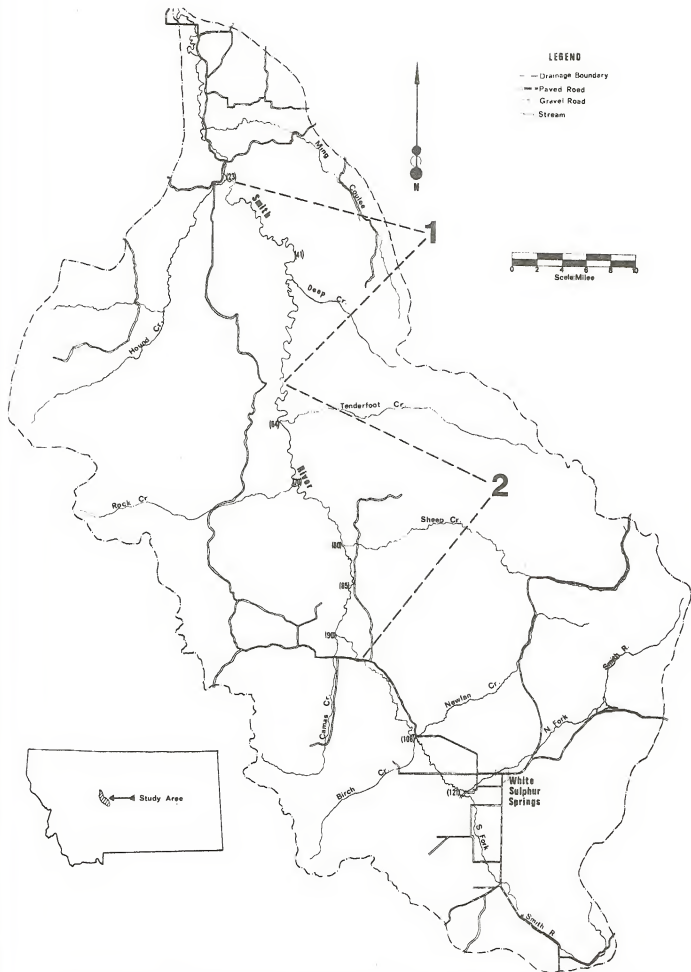


Figure 50. Smith River drainage. Approximate river miles in parentheses.

Flows ranged from 3.1 to 12,300 cfs. Flows at this gage reflect the dewatering that occurs during the summer irrigation season.

All waters in the Smith River drainage have been appropriated for irrigation and domestic use. As in other areas of the state, appropriations are several times the amount of water actually present. The dewatering of the Smith River during the summer irrigation season is probably the greatest factor limiting present game fish populations. The augmentation of summer flows by properly planned on or offstream storage facilities in the upper Smith River drainage is one possible solution for improving the fishery resource.

Presently the water quality of the Smith River is generally good. A future threat to water quality is the poorly planned recreational homesite development that is occurring along the river. The loose alluvial materials found at many of the good construction sites will result in the rapid leaching of sewage effluent into the river.

Elevated summer water temperatures primarily resulting from dewatering and warm irrigation return flows are undoubtedly affecting the trout fishery of the Smith River. Temperatures above 70 F, which are considered undesirable for trout populations, commonly occur throughout the river. Water temperatures as high as 80 F have been recorded.

The annual sediment yield to the Smith River is considered moderately low. However, unnecessary seasonal sediment problems do occur. Severely gullied diversion ditches, early placer mining areas, raw banks along the rechanneled sections of the river, and land erosion resulting from the destruction of the protecting vegetative cover by overgrazing, extensive clearcut logging, road building and homesite development are some obvious sources of sediment to the Smith River drainage. Sediment adversely affects aquatic ecosystems in several different ways. For example, filling spaces between stones in the streambed gravels eliminates habitat for aquatic invertebrates. Sediment also interferes with trout egg incubation by restricting flow through the stream gravel, thus reducing the oxygen supply. There is some evidence of trout reproductive failure and low aquatic invertebrate populations in the upper half of the South Fork of the Smith River as a result of sediment pollution.

The Smith River offers sport fishing for rainbow trout, brown trout, mountain whitefish and an occasional brook and cutthroat trout. The mountain whitefish is the most numerous game fish. Rainbow trout, the predominant trout species, are the mainstay of the sport fishery throughout the river. The rainbow trout creel by anglers rarely exceed 2 pounds with the majority in the 10 to 14 inch class. Brown trout, which provide the trophy fishery, commonly reach weights of 2 pounds with specimens up to 10 pounds reported. Other fish present include longnose sucker, white sucker, mountain sucker, longnose dace, stonecat, burbot, and mottled sculpin. A few carp are present in the lower river.

Estimates of the numbers of 1 year and older trout in sections of the Smith River range from 40 to 117 per 1,000 ft of river. Trout biomass estimates range from 26.0 pounds to 55.2 pounds per 1,000 ft (Wipperman 1973).

Limited public access strongly influences the recreational use of the Smith River. The river lacks the developed access sites and recreational areas that characterize many other rivers of Montana. As a result, float fishing and boating are the most popular recreational activities. The float season usually begins about the first of July after the crest of spring runoff and continues until about mid-August when water levels become too low for floating.

The Smith River still receives substantial angler use in spite of access and environmental problems. Fishing pressure in fisherman days was estimated at 11,217 between May 1, 1968 and April 30, 1969 and 10,924 between May 1, 1975 and April 30, 1976 (MDFG 1969 and 1975). Angler success is about three fish per angler day.

The lands adjacent to the Smith River support a variety of wildlife. The canyon portion of the river provides winter range for mule deer and elk from the Big and Little Belt mountains in addition to supporting a resident mule deer population. The canyon area also supports a variety of other wildlife associated with riverbottoms. White-tailed deer, ring-necked pheasant and sharp-tailed grouse are commonly found along the lower river where shrubby vegetation interspersed with agricultural lands provides excellent habitat.

A 1969 state law (Section 89-801, R.C.M. 1947) authorized the Montana Department of Fish and Game to appropriate water for instream uses on 12 rivers in the state. On the Smith River between the mouth of Hound Creek (T17N, R3E, Sec. 20) and the Cascade County line (T15N, R3E, Sec. 36), the department appropriated 400 cfs from April 1 to August 31 and 150 cfs from September 1 to March 31. Between the Meagher-Cascade County line (T14N, R3E, Sec. 1) and the Fort Logan Bridge (T11N, R5E, Sec. 31), the department appropriated 150 cfs from April 1 to August 31 and 125 cfs from September 1 to March 31. However, these appropriations have little impact on the fishery since the water is already controlled by the holders of senior water rights. Presently, there is little opportunity for increasing summer flows in the Smith River without constructing storage reservoirs or changing water uses from agricultural to instream.

A thorough discussion of the environmental problems affecting the Smith River drainage and the recreational resource is provided by Wipperman (1973) and the Governor's Council on Natural Resources and Development (1970).

3. REACH #1

From the mouth of Hound Creek to the Cascade County line. (T17N, R3E, Sec. 20 to T15N, R3E, Sec. 36)

Method Used For Flow Recommendation

Flow recommendations for the July 1 to April 30 period are based solely on the instream flows appropriated under state law by the Montana Department of Fish and Game (see GENERAL DESCRIPTION). As methodologies are developed, additional information will be gathered to justify these flow recommendations.

Flow recommendations during the high water period (May 1 to June 30) will be based on the dominant discharge/channel morphology concept (see page 5). This information will be available when flow records for the USGS gage near Eden are summarized.

Flow Recommendations

The bankfull flow, estimated at 1,487 cfs, should be established for 24 hours during June 1-15. During the remainder of the high water period (May 1 - June 30), the 70% exceedance flows, presently undetermined, are recommended (see page 5).

The recommended instream flows for reach #1 of the Smith River are partially identified in Table 32. The recommended flows are similar to or exceed the mean monthly flows for January, February, April, July, August, September, November, and December (Table 32). The mean monthly flows for this reach reflect the dewatering that occurs during the summer irrigation season.

4. REACH #2

From the Meagher-Cascade County line to the Fort Logan Bridge. (T14N, R3E, Sec. 1 to T11N, R5E, Sec. 31)

Method Used For Flow Recommendations

Flow recommendations for the July 1 to April 30 period are based solely on the instream flows appropriated under state law by the Montana Department of Fish and Game (see GENERAL DESCRIPTION). Flow recommendations for the high water period (May 1 - June 30) will be based on the dominant discharge/channel morphology concept (see page 5). The information needed to derive flow recommendations for this period is unavailable due to the lack of USGS flow records for reach #2.

Flow Recommendations

The bankfull flow, presently undetermined, should be established for 24 hours during June 1-15. During the remainder of the high water period (May 1 - June 30), the 70% exceedance flows, presently undetermined, are recommended (see page 5).

The recommended instream flows for reach #2 of the Smith River are partially identified in Table 33.

Table 32. Instream flow recommendations compared to mean monthly flows for reach #1 of the Smith River.

Time Period	Recommended Flow		Mean	
	CFS	AF	CFS	AF
January	150	9,223	99.4	6,112
February	150	8,628	137	7,880
March	150	9,223	179	11,006
April	400	23,802	393	23,385
May	<u>1/</u>		955	58,721
June	<u>1/</u>		1,190	70,810
July	400	24,595	374	22,996
August	400	24,595	158	9,715
September	150	8,926	154	9,164
October	150	9,223	169	10,391
November	150	8,926	150	8,926
December	150	9,223	110	6,764
Total				245,870

1/ Flows presently unidentified.

Table 33. Instream flow recommendations for reach #2 of the Smith River.

Time Period	Recommended Flow	
	CFS	AF
January	125	7,686
February	125	7,190
March	125	7,686
April	150	8,926
May	<u>1/</u>	
June	<u>1/</u>	
July	150	9,223
August	150	9,223
September	125	7,438
October	125	7,686
November	125	7,438
December	125	7,686
<u>1/</u> Flows presently unidentified.		

1. RIVER

Marias River

2. GENERAL DESCRIPTION

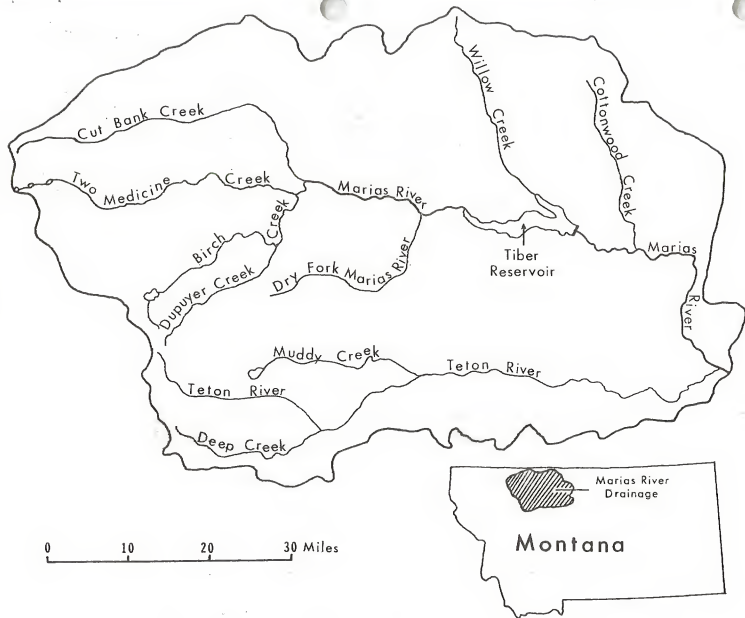
The headwaters of the Marias River originate in the Rocky Mountains of northern Montana. Tributaries of the Marias drain a large part of the eastern slopes of the Continental Divide in Glacier National Park and the adjoining Lewis and Clark National Forest before flowing eastward through the broad, rolling plains of north central Montana (Figure 51). The main stem of the Marias River forms at the junction of Two Medicine and Cut Bank creeks, 12 miles north of Valier, Montana. The Marias River then flows east and south to its confluence with the Missouri River, 192 miles downstream. Of this distance, the river flows approximately 50 miles from its origin before discharging into Tiber Reservoir, a large man-made impoundment in the north central portion of the drainage. After leaving Tiber Reservoir, the river flows 68 miles before discharging into the Missouri River near Loma, Montana.

The Marias River basin is about 140 miles long and 80 miles wide with a drainage area of approximately 9,100 square miles. A noticeable peculiarity of the drainage is the absence of marked foothill development. There is an abrupt transition from the mountains to the plains stretching to the east. The mountain streams in the drainage flow through rugged, relatively immature valleys surrounded by snowcapped peaks. Conversely, the streams flowing through and originating in the plains are located in relatively mature valleys, flanked on either side by bluffs as high as 200 ft (MDHES 1975).

All of the streams in the Marias River drainage flow essentially east and south. The principal tributary of the Marias River, the Teton River, enters the Marias River 0.8 mile upstream from its confluence with the Missouri River near Loma, Montana. Other major tributaries entering the Marias River include Cut Bank Creek, Two Medicine Creek and Dry Fork of the Marias River above Tiber Reservoir, Willow Creek emptying into Tiber Reservoir, and Cottonwood Creek below Tiber Dam.

Mean annual discharge of the Marias River is approximately 0.8 million acre feet (1,105 cfs) (USGS 1978). However, the present day flow regime is not entirely natural because of regulation and storage in Tiber Reservoir. Tiber Reservoir is by far the largest impoundment in the drainage, and it has a storage capacity of 11,368,000 acre-feet. Including Tiber, a total of 11 reservoirs in the basin have storage capacities of 1,000 acre-feet or more. Nine of these are used primarily for

Figure 51. Map of Marias River drainage.



irrigation purposes. The reservoirs have an estimated total storage capacity of 11,649,457 acre-feet.

The largest user of water in the Marias basin is irrigated agriculture. This requires an annual diversion of approximately 780,500 acre feet of water from streams and reservoirs in the drainage. Net depletion, including crop requirements, delivery loss and evaporation, amounts to 368,000 acre-feet per year. A total of 412,500 acre-feet per year, or 53% of the total diversion requirement, is eventually returned to the streams (MDHES 1975).

Municipal water use in the drainage is estimated at a total of 3,935 acre-feet per year. Of this amount, 1,751 acre-feet, or 44.5%, is derived from surface water sources, and the remainder comes from groundwater. Industrial water use within the Marias River basin is presently insignificant (MDHES 1975).

The Marias River drainage contains most of the fish species found east of the Continental Divide in Montana. A total of 39 species representing 12 families of fish are known to occur in the drainage (Table 34). The headwaters streams and lakes are inhabited primarily by cold water species including rainbow, brook, cutthroat and brown trout, mountain whitefish and mottled sculpin. Grayling are present in a few lakes. The cold water fishery extends downstream in the drainage generally to Tiber Reservoir. The presence of Tiber Dam precludes the development of a well developed transition zone between the cold water and warm water fishery. While some trout are found in the Marias River immediately below Timber Dam, most of the species inhabiting this reach are indicative of warm water conditions. These species include shovelnose sturgeon, channel catfish, goldeye, blue sucker, shorthead redhorse, longnose sucker, carp, river carpsucker, big-mouth and smallmouth buffalo, and a variety of minnows. Walleye, sauger, yellow perch, burbot and northern pike are found locally throughout the entire Marias River drainage, but their principal distribution is within Tiber Reservoir and in the Marias River below Tiber Dam. Paddlefish are occasionally found in the lower Marias River as far upstream as Tiber Dam.

3. STREAM REACH

From Sheep Coulee to the mouth of the Teton River.
(T27N, R8E, NW¼, Sec. 15 to T25N, R9E, SE¼, Sec. 12)

Description

The Marias River in the 21.2 mile reach of stream between Sheep Coulee and the mouth of the Teton River flows through a gorge-like river valley, which lies 300 to 400 feet below the average elevation of the adjacent plains. The relatively mature valley is comprised largely of varied and scenic badlands and breaks areas ranging from 1 to 3 miles in width. The Marias River has an average width of 150 feet through this section. The stream gradient averages 3.41 feet per mile and varies from 3.1 to

Table 34. Fish species recorded for the Marias River drainage in Montana (family, scientific and common names).

ACIPENSERIDAE (Sturgeon family)

Scaphirhynchus platyrhynchus - Shovelnose sturgeon

POLYODONTIDAE (Paddlefish family)

Polyodon spathula - Paddlefish

HIODONTIDAE (Mooneye family)

Hiodon alosoides - Goldeye

SALMONIDAE (Trout family)

Prosopium williamsi - Mountain whitefish

Oncomorhynchus nerka - Kokanee

Salmo clarkii - Cutthroat trout

Salmo gairdneri - Rainbow trout

Salmo trutta - Brown trout

Salvelinus fontinalis - Brook trout

Thymallus arcticus - Artic grayling

ESOCIDAE (Pike family)

Esox lucius - Northern pike

CYPRINIDAE (Minnow family)

Cyprinus carpio - Carp

Carassius auratus - Goldfish

Semotilus margarita - Pearl dace

Phoxinix eos - Northern redbelly dace

Phoxinix neogaeus - Finescale dace

Hybopsis gracilis - Flathead chub

Couesius plumbeus - Lake chub

Notropis atherinoides - Emerald shiner

Hybognathus placitus - Plains minnow

Hybognathus nuchalis - Silvery minnow

Pimephales promelas - Fathead minnow

Rhinichthys catarractae - Longnose dace

CATOSTOMIDAE (Sucker family)

Carpoides carpio - River carpsucker

Cycleptus elongatus - Blue sucker

Ictiobus bubalus - Smallmouth buffalo

Ictiobus cyprinellus - Bigmouth buffalo

Moxostoma macrolepidotum - Shorthead redhose

Catostomus catostomus - Longnose sucker

Catostomus commersoni - White sucker

Catostomus platyrhynchus - Mountain sucker

ICTALURIDAE (Catfish family)

Ictalurus punctatus - Channel catfish

Noturus flavus - Stonecat

Table 34 continued. Fish species recorded for the Marias River drainage in Montana (family, scientific and common names).

GADIDAE (Codfish family)

Lota lota - Burbot

PERCIDAE (Perch family)

Perca flavescens - Yellow perch

Stizostedion canadense - Sauger

Stizostedion vitreum - Walleye

SCIAENIDAE (Drum family)

Aplodinotus grunniens - Freshwater drum

COTTIDAE (Sculpin family)

Cottus bairdi - Mottled sculpin

3.8 feet per mile. The stream substrate type ranges from fine silt in some of the quiet pool areas to large cobbles in the high gradient riffles. However, gravel and small cobble is the predominant substrate throughout most of the reach. No major tributaries enter the Marias River in this reach.

Fishery

The Marias River in this reach supports a substantial warm water fishery. The most common resident game fish are shovelnose sturgeon, channel catfish, walleye, sauger and burbot. A few northern pike are also found occasionally in the reach. The most common nongame fish are goldeye, longnose dace, and flathead chub.

In addition to the resident fish populations, this portion of the Marias River provides spawning areas for a number of fish species which migrate from the Missouri River and Fort Peck Reservoir. Spawning migrations of sauger, shovelnose sturgeon, blue sucker, bigmouth buffalo and smallmouth buffalo have been documented in studies conducted by the Montana Fish and Game Department. These studies were initiated in an effort to better understand the ecological relationship between the Missouri and lower Marias rivers. Spawning migrations have been monitored by electrofishing and frame trapping during 1976, 1977 and 1978.

During years when the spring runoff is of sufficient duration and magnitude, paddlefish are found in this reach of the Marias River. The paddlefish migrate upstream from Fort Peck Reservoir into the Missouri River system during the runoff period, presumably to spawn. Paddlefish have been observed in the Marias River as far upstream as Pondera Coulee and Tiber Dam (Brown 1971). These sites are located 60 and 68 miles upstream from the mouth of the Marias River, respectively.

The Marias River in this reach supports an important sport fishery, particularly during the spawning migration periods. The most sought-after species include sauger, shovelnose sturgeon, channel catfish and burbot. A Montana state record shovelnose sturgeon weighing 12.8 pounds was taken in this reach of the Marias River on July 1, 1978. The sport fishery in this area is presently underutilized, but its potential recreational value is substantial.

The lower Marias River is also utilized for floating, primarily during the spring and early summer. Due largely to the rugged, inaccessible terrain, the land contiguous to the Marias River in this reach has retained most of its primitive characteristics offering excellent scenic values to the floater. Floating is often done in conjunction with fishing and camping.

Waterfowl

Several species of waterfowl are dependent on this reach of the Marias River for rest stops during migration. These include the Canada goose, mallard, pintail, scaup, bufflehead, common merganser, common goldeneye and others. Several of these species also nest in the area.

Wildlife

Aquatic associated mammals found in this reach of the Marias River include muskrat, mink and beaver. Mammals associated with the riparian habitat along the river include mule deer, white-tailed deer, raccoon and fox. Bald eagles winter along the river in this reach.

Shore birds which seasonally frequent the area include killdeer, yellowlegs, a variety of sandpipers and phalarope. Several species of gulls and terns as well as great blue herons and kingfishers are found along the river during the warmer months.

Environmental Concerns

In general, the environmental quality of this reach of the Marias River can be considered good. However, there are a number of human related practices which can contribute to water quality degradation and affect aquatic life in the drainage. These include nutrient enrichment of surface water from sewage treatment facilities, drainage of wastes from agricultural lands, oil contamination and, possibly saline seeps.

There are 19 sewage collection facilities in the Marias River drainage, 12 of which have a discharge from the associated sewage treatment facility. The Montana Department of Health and Environmental Sciences has recommended that most of the communities in the Marias River basin need to upgrade their sewage treatment facilities (MDHES 1975). If secondary levels of treatment could be achieved at these facilities, nutrient enrichment of some streams could be reduced.

Agricultural waste problems include irrigation return flows, animal wastes, and runoff from farm land treated with pesticides, herbicides and fertilizer. The effect of agricultural wastes on surface water quality and upon aquatic life in the Marias basin is difficult to determine and generally will require more investigation. However, high sediment yields in several tributaries to the Marias River have been definitely identified as problems related at least in part to agriculture (MDHES 1975).

Oil exploration and development is a major activity in the Marias River basin. Contamination of surface waters with oil can occur due to leakage at the drilling sites or pipeline breaks. Oil contamination problems are presently confined to seeps from drill holes into some pothole lakes near Cut Bank in the northwestern portion of the drainage. However, continuous monitoring of oil development projects will be required to avert potential future

contamination problems.

A great potential for water quality degradation and damage to aquatic life exists from saline seeps. Saline seep is known to occur in every county in the Marias drainage, but it is unknown if any of the seep areas are a problem to aquatic life at this time.

Methods Used For Flow Recommendations

The wetted perimeter method was used to identify the high and low levels of aquatic habitat potential for the months of August through March (see page 7 for a detailed explanation of the wetted perimeter method). Five cross sections were surveyed in a 2,924-foot reach of the lower Marias River in T25N, R9E, NE¼, Sec. 9 and NW¼, Sec. 10. Wetted perimeter projections at various flows were generated by the IFG4 Hydraulic Simulation Program.

Flow recommendations for the months of April, May, June and July will be equivalent to the 70 percent exceedance flow averaged for 2 week periods. These flows have not yet been determined, but they will be calculated when data becomes available from the USGS (1978).

Flow recommendations for the month of June were based on the dominant discharge/channel morphology concept (see page 5 for a detailed explanation). The flows were calculated from data supplied by the USGS (1978). The 1½ year frequency peak flow was used to approximate the bankfull condition.

Flow Recommendations

The relationship between wetted perimeter and discharge for a composite of five cross-sections of the lower Marias River is shown in Figure 52. The two inflection points identified in the figure occur at flows of approximately 210 and 375 cfs. These flows correspond to the low and high levels of aquatic habitat potential, respectively, for the months of August through March.

The 70 percent exceedance flow is recommended for the months of April, May, June and July. The extended high flow period is necessary to maintain spawning, incubation and rearing areas for resident and migrant fish populations in this reach (Berg 1976, 1977 and 1978). Also, it is doubtful, if not impossible, that the important warm water fishery on the lower Marias River could be maintained without these flows. The bulk of the fishing pressure in this area occurs during the spawning migration periods, primarily from April through July.

The bankfull discharge for the lower Marias River as estimated from the 1½ year frequency flood (USGS 1978) is 2,160 cfs. This flow should be established for a 24-hour period during June. This flow is necessary to maintain channel morphology and aquatic habitat values in the lower Marias River.

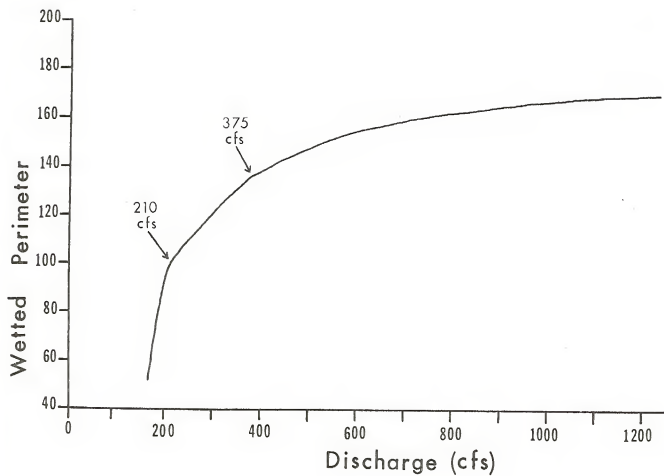


Figure 52. Wetted perimeter versus discharge for five cross-sections of the lower Marias River.

Instream flows which will maintain high and low levels of aquatic habitat potential in this reach of the Marias River are summarized and compared to mean monthly flows in Table 35. For all months of the year except January, mean monthly flows in the lower Marias River exceed the recommended instream flows. During January, the mean monthly flow is 78 cfs less than the flow recommended to maintain a high level of aquatic habitat potential. Because of the extraordinary natural, recreational and scenic values of the lower Marias River, it is strongly recommended that flows in this reach be maintained at the high level of aquatic habitat potential.

Table 35. Instream flow recommendations for low and high levels of aquatic habitat potential compared to mean monthly flows for the lower Marias River from Sheep Coulee to the mouth of the Teton River.

Time Period	Low ^{1/}		High ^{2/}		Mean	
	CFS	AF	CFS	AF	CFS	AF
January	210	12,912	375	23,058	297	18,262
February	210	11,663	375	20,826	379	21,048
March	210	12,912	375	23,058	598	36,769
April	*		*		899	53,494
May	*		*		1570	96,535
June	* ^{3/}		* ^{3/}		2035	121,091
July	*		*		1315	80,856
August	210	12,912	375	23,058	981	60,319
September	210	12,496	375	22,314	950	56,529
October	210	12,912	375	23,058	822	50,543
November	210	12,496	375	22,314	640	38,083
December	210	12,912	375	23,058	381	23,427
Total						656,956

1/ Low level of aquatic habitat potential.

2/ High level of aquatic habitat potential.

3/ June includes a 24-hour period of bankful flow of 2160 cfs.

1. RIVER

Musselshell River

2. GENERAL DESCRIPTION

The Musselshell River drainage (Figure 53) is situated in central Montana where surrounding topography is characterized by mountains in the west, rolling plains in central portions and badlands in the northeast.

Headwater tributaries flow from the Little Belt, Castle and Crazy mountains, forming the North and South Forks of the Musselshell. Near the town of Martinsdale the two forks converge, flow easterly and then northward emptying into Fort Peck Reservoir on the Missouri River. From its origin at 9,000 feet to the mouth at 2,200 feet, the Musselshell flows a river distance of 292 miles and has an average annual discharge of 172,000 acre feet.

Land use in the drainage is limited mainly to livestock grazing with modest farming activities. Some coal mining occurs in the southeastern region of the basin, with moderate oil production to the north.

Problems with water quality in the river are attributed to agricultural runoff and irrigated returns which cause increases in salinity, nutrient levels and sediment. These in turn contribute to high water temperatures and turbidities, while decreasing dissolved oxygen levels.

A wide variety of wildlife can be found in the Musselshell River basin. The mountain regions contain significant populations of big game species such as elk, mule deer, black bear and mountain goat. Blue, ruffed and Franklin's grouse are also common. Furbearers are numerous here as well as in the plains regions. Antelope and upland game birds are also abundant at these lower elevations. Riparian wildlife species include mink, muskrat, otter, beaver, and in heavily vegetated areas, white-tailed deer and ring-necked pheasants maintain impressive populations.

More than 20 species of fish inhabit the Musselshell River of which seven are game species. These include brook, brown, rainbow and cutthroat trout in the cold water reaches, and sauger, smallmouth bass and channel catfish in the warm water areas.

To provide accurate and credible flow recommendations, the Musselshell was divided into three biotic zones or reaches: warm water, transitional and cold water zones.

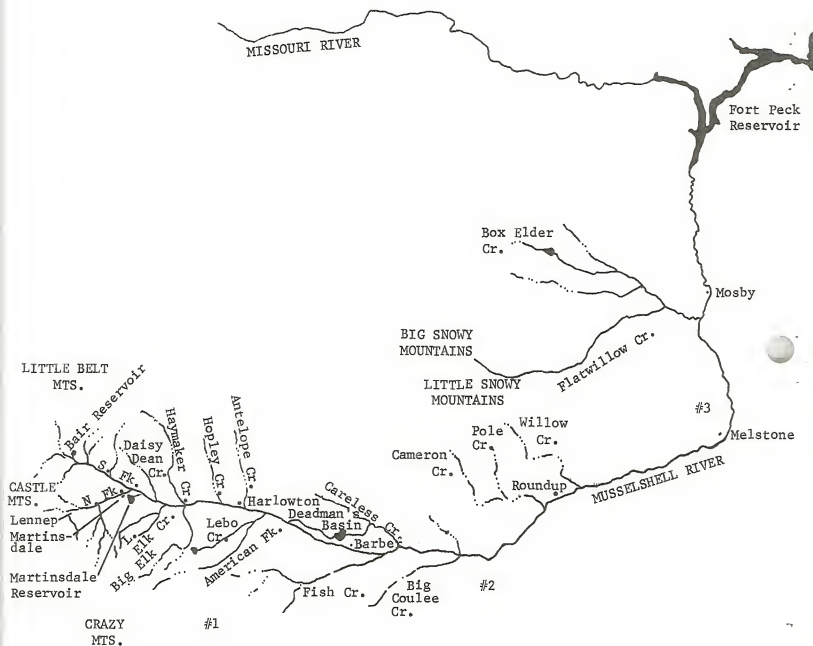


Figure 53. Musselshell River drainage.

3. REACH #1 (cold water zone)

From the headwaters to Barber
(T8N,R12E,Sec.6 to T6N,R19E,Sec.6)

Description

The Musselshell River from its headwater tributaries in the Little Belt, Castle and Crazy mountains to the town of Barber is approximately 80 miles in length. The average width of the mainstem downstream from the convergence of the North and South Forks is 60 feet. The average gradient for this zone is 20.5 feet per mile with cobble and gravel being the most predominant substrate type. Most of the zone is between 4,000 and 6,000 feet in elevation.

Major tributaries from the south include Little Elk, Big Elk, Lebo and American Fork creeks and from the north include Daisy Dean, Haymaker, Hopley and Antelope creeks.

Several storage reservoirs have been constructed to alleviate dewatering and to provide additional irrigation water to the Musselshell: Bair Reservoir on the North Fork, Martinsdale Reservoir on the South Fork and Deadman's Basin, fed by a diversion from the main river. Total storage capacity of these reservoirs is 82,214 acre feet; however, none are large enough to provide complete regulation of flows (MEO 1950).

Major diversions include the following:

Duncan-Smart Ditch	30	cfs	Fochs Irrigation System	45	cfs
G. L. Mutual Ditch	48	cfs	Winnecook-Webster-		
Muir-Klock Ditch	15	cfs	Bridges Ditch	90	cfs
Muir Mutual Ditch	22.5	cfs	Deadman's Basin Canal	600	cfs
O.K. Private Irrigation			Bair Reservoir Canal	51	cfs
System	30	cfs	Martinsdale Reservoir		
Penwell-Ross Irrigation			Canal	400	cfs
System	70	cfs			

Fishery

The cold water region of the Musselshell supports five different species of sport fish which include a native cutthroat population and mountain whitefish. It is generally considered to be an average to above-average fishery.

The South Fork has long enjoyed a reputation among local residents as being a good fishery. The streambottom has good gravel bars with little silt and abundant brush cover. Adequate habitat for trout persists even when water levels are low. In the upper reaches of the South Fork, brook, rainbow and brown trout make up a significant portion of the fishery with brook trout comprising 56% of the population. Further downstream in the South Fork near Martinsdale, brown trout make up 96% of the trout population and rainbow the remainder (Johnson 1968).

The North Fork's excellent willow cover and undercut banks provide good habitat for brown, rainbow and brook trout. Brown trout comprise 70% of the existing trout population (Johnson 1968).

Below the town of Martinsdale on the main stem of the river, the trout fishery consists mainly of brown trout with the remainder being rainbow and mountain whitefish. Trout comprise 22% of the fish population in the upper portions of this area (Welch 1961).

Most of the larger reservoirs in the cold water reach of the Musselshell contain introduced populations of trout, rainbow trout being the most abundant species.

Waterfowl

Ducks and geese utilize the Musselshell River for breeding and during mild winters may remain the entire season. Great blue heron, along with innumerable species of shore birds, are common to this zone.

Wildlife

See GENERAL DESCRIPTION

Environmental Concerns

Generally, habitat on the South Fork is good with the exception of channelization near Lennep. In other portions of the stream, brush cover along streambank and streambed is adequate and sedimentation is not critical. There are, however, localized problems with silt due to the influence of the North Fork diversion canal which joins the South Fork near the Town of Martinsdale. Bank erosion in a nearby area has caused cottonwood trees to fall altering flow patterns. During summer months a problem exists as a result of a diversion headgate for Martinsdale Reservoir, below which flows may be completely cut off.

On the North Fork, bank cover is abundant but heavy silt deposits continue to be a problem, especially near the junction with the South Fork. Bair Reservoir produces erratic flows which adversely affect fish populations (Hill 1971).

The mainstem from Martinsdale to Harlowton occasionally suffers substantial flow reductions in mid and late summer due to intensive irrigation practices. Brush cover at streambanks and streambeds is good in the upper regions of the reach and is lacking in lower areas where livestock have destroyed it. Heavy sediment loads are common during spring runoff and summer irrigation runoff.

Method Used For Flow Recommendations

The wetted perimeter method was used to determine the high and low level of aquatic habitat potential. Five cross-sections were surveyed below Martinsdale on the mainstem of the Musselshell (T8N, R12E, Sec.9). The wetted perimeter projections at various flows were produced by the Water Surface Profile Program (page 7).

Future flow recommendations for the high water period (May 1 - June 30) will be based on the dominant discharge/channel morphology concept (see page 5). The information needed to derive these flows is presently unavailable.

Flow Recommendations

A graph of wetted perimeter versus discharge for the five cross-sections of the Musselshell River in reach #1 is shown in Figure 54. The two inflection points occur at approximate flows of 40 and 70 cfs and correspond to the low and high level of aquatic habitat potential, respectively.

The bankfull flow for reach #1, estimated by the 1 $\frac{1}{2}$ -year frequency peak flow, is about 696 cfs. This flow should be established for 24 hours during June. For the remainder of the high water period (May 1 - June 30), the 70% exceedance flows are recommended. This information, presently unavailable, will be available when flow records for the USGS gage at Harlowton are summarized.

The instream flows that will maintain a low and high level of aquatic habitat potential are partially identified in Table 36. Instream flows recommended for reach #1 of the Musselshell River correspond to a high level of aquatic habitat potential. The recommended flows for the months of August through February are similar to or slightly exceed the mean monthly flows (Table 36). Any additional water withdrawals during this period may negatively affect the fishery and other aquatic biota by providing less water than what is deemed necessary to sustain a high level of aquatic habitat potential.

4. REACH #2 (Transitional zone)

From Barber to Roundup
(T6N, R19E, Sec.6 to T8N, R25E, Sec.22).

Description

The reach of the Musselshell River between Barber and Roundup is 50 miles long and has an average width of approximately 85 ft. The average gradient is 6.6 ft per mile with the most common substrate type being gravel and isolated spots of broken sandstone slabs. The majority of this zone is located between the 3,000 to 4,000 foot elevation level. Major tributaries flowing into the Musselshell in this area include Fish, Big Coulee, Cameron, Pole and Careless creeks.

Major diversions include the following:

Lavina Canal	87.5 cfs
Sims Mutual Ditch	37.5 cfs
Slayton Mutual Ditch Co.	25.0 cfs
Newton Canal	50.0 cfs

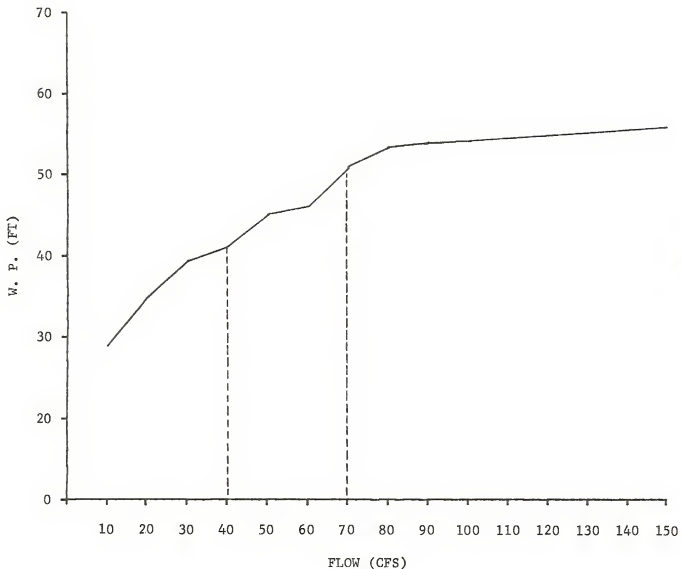


Figure 54. The relationship between wetted perimeter and flow for a composite of five cross-sections in reach #1 of the Musselshell River.

Table 36. Instream flows representing low and high levels of aquatic habitat potential compared to mean monthly flows for reach #1 of the Musselshell River.

Time Period	Low ^{1/}		High ^{2/}		Mean	
	CFS	AF	CFS	AF	CFS	AF
January	40	2,460	70	4,304	59	3,628
February	40	2,300	70	4,026	63	3,624
March	40	2,458	70	4,302	118	7,256
April	40	2,379	70	4,165	195	11,603
May	3/		3/		435	26,747
June	3/		3/		531	31,597
July	40	2,458	70	4,304	154	9,469
August	40	2,458	70	4,304	69	4,243
September	40	2,379	70	4,165	60	3,570
October	40	2,458	70	4,304	74	4,550
November	40	2,379	70	4,165	81	4,820
December	40	2,458	70	4,304	69	4,243
Total						115,350

1/ Low level of aquatic habitat potential.

2/ High level of aquatic habitat potential.

3/ Flows presently unidentified.

Fishery

Trout are scarce in the transitional zone, especially in the lower sections where water temperatures can remain in the 80's for extended periods. Warm water game fish such as channel catfish and sauger are more numerous, but still comprise an insignificant percentage of the total population. The reason for the obvious absence of these warm water game species is still a matter of conjecture. The recent introduction of small-mouth bass into the lower portion of this reach will hopefully produce a self-sustaining population in future years. Although warm water and cold water game fish are scarce, the area maintains a high level of productivity and supports a substantial forage and rough fish population.

Waterfowl

See Description under reach #1.

Wildlife

See GENERAL DESCRIPTION.

Environmental Concerns

Aquatic habitat conditions are fair in this reach. Banks are stable in most areas except where livestock are allowed access to the river. At these locations, vegetation has been reduced to a point where erosion is inevitable. The most abundant types of riparian vegetation are honeysuckle, wild rose, willow and isolated groves of cottonwood trees.

High turbidity occurs during spring runoff and remains high until late summer due to irrigation returns.

Flows have fluctuated significantly over the 33 years of records at the USGS gage at Roundup (T8N, R25E, Sec.22). These erratic flows have reduced aquatic productivity throughout the reach.

The scarcity of warm water game fish species in this area may be due to several irrigation diversion dams on the mainstem which have inhibited movement from the lower reach where these species are more numerous.

Methods Used for Flow Recommendations

In this reach, as in the previous one, the wetted perimeter method was used to determine the high and low level of aquatic habitat potential (page 7). Five cross-sections were surveyed at Cow-Belle Park (T8N, R22E, Sec. 13) on the Musselshell River. The wetted perimeter projections were generated by the Water Surface Profile Program (page 7).

Future flow recommendations for the high water period (May 1 - June 30) will be based on the dominant discharge/channel morphology concept (see page 5). The information needed to

derive these flows is presently unavailable.

Flow Recommendations

The relationship between wetted perimeter and discharge for five cross-sections of the Musselshell River in reach #2 is depicted in Figure 55. The inflection points shown in this figure occur at flows of approximately 50 cfs and 100 cfs and correspond to the low and high levels of aquatic habitat potential, respectively (see page 7).

The bankfull flow for reach #2, presently undetermined, should be established for 24 hours during June. For the remainder of the high water period (May 1 - June 30), the 70% exceedance flows, presently undetermined, are recommended. This information will be available when flow records for the USGS gage at Roundup are summarized.

The instream flows that will maintain a low and high level of aquatic habitat potential are partially identified in Table 37. Instream flows recommended for reach #2 of the Musselshell River correspond to a high level of aquatic habitat potential. The recommended flows exceed the mean monthly flows for the months of October through January (Table 37). Any additional water depletions during this period may severely affect the aquatic resource.

5. REACH #3 (Warm water zone)

From Roundup to the mouth (T8N, R25E, Sec. 22 to T17N, R29E, (T8N, R25E, Sec.22 to T17N,R29E, Sec. 17).

Description

This reach extends from Roundup to the mouth of the Musselshell, a distance of approximately 90 miles. The average width is 100 ft and average gradient is 3 ft per mile. The substrate is composed mainly of silt and sand with some interspersions of gravel in isolated locations. Most of this zone is below 3,000 ft.

Major tributaries include Willow, Flatwillow and Box Elder creeks.

Major diversions include the following:

Musselshell-Melstone Canals	235 cfs
Cooley-Goffena Irrigation System	50 cfs
Goffena-Sudan Ditch	58 cfs
Musselshell Ditch Co.	50 cfs
Naderman Ditch Co.	25 cfs

Fishery

The warm water reach not only supports a substantial resident fish population, but also provides spawning areas for sauger and

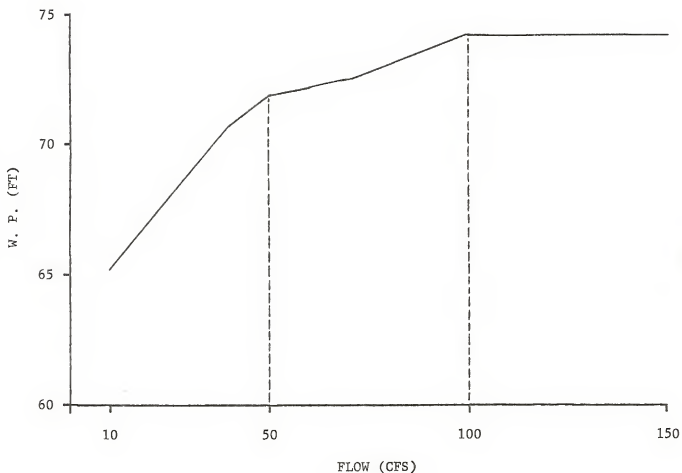


Figure 55. Relationship between wetted perimeter and flow for a composite of five cross-sections in reach #2 of the Musselshell River.

Table 37. Instream flows representing low and high levels of aquatic habitat potential compared to mean monthly flows for reach #2 of the Musselshell River.

Time Period	Low ^{1/}		High ^{2/}		Mean	
	CFS	AF	CFS	AF	CFS	AF
January	50	3,074	100	4,309	64	3,984
February	50	2,877	100	4,031	105	6,039
March	50	3,074	100	4,309	175	10,778
April	50	2,976	100	4,170	190	11,305
May	<u>3/</u>		<u>3/</u>		400	24,595
June	<u>3/</u>		<u>3/</u>		689	41,028
July	50	3,075	100	4,309	274	16,884
August	50	3,075	100	4,309	199	12,262
September	50	2,976	100	4,170	131	7,824
October	50	3,075	100	4,309	79	4,864
November	50	2,976	100	4,170	79	4,736
December	50	3,075	100	4,309	70	4,322
Total						148,621

1/ Low level of aquatic habitat potential.

2/ High level of aquatic habitat potential.

3/ Flows presently unidentified.

channel catfish which migrate from Fort Peck Reservoir. This seasonal migration of channel catfish may take them over 60 miles upstream from the river's mouth. The actual migration of sauger has not been documented at this time, but is highly probable.

The most common game fish are channel catfish and sauger. Black crappie are also present and the recent introduction of small-mouth bass from Roundup to Melstone promises to produce a self-sustaining population within a few years.

The largest percentage of fish in this area are of the rough fish category, with goldeye and carp being the most abundant.

A reconnaissance report undertaken by the Bureau of Sport Fisheries and Wildlife (Burwell 1963) estimates fisherman-days on the lower 80 miles of the Musselshell to be 2,360 annually. It also reports that good fishing is available in this region during favorable flows, but biological productivity is impaired due to erratic discharges.

Waterfowl

See Description under REACH #1.

Wildlife

See GENERAL DESCRIPTION.

Environmental Concerns

Problems with water quality in this zone are more acute than those upstream. Suspended solids and turbidity increase progressively downstream, but at or near the town of Roundup they begin to rise more rapidly reaching their highest levels near Mosby. This reach also has higher salinities and conductivities than those found in upstream reaches.

The upper portion of this warm water reach has riparian vegetation very similar to that found in the transitional zone. Livestock grazing on banks and characteristics inherent to the surrounding soils contribute to a water quality problems mentioned above.

In the lower areas of this zone an arid climate with unstable and saline soils provides an inhospitable environment for most vegetation. This situation is especially apparent in the breaks, where contributions of sediment are the highest of the entire Musselshell subbasin (BLM 1971).

Dewatering continues to be a problem here as it was in the upper reaches. Fifty years of USGS flow records at Mosby (T14N, R30E, Sec. 11) show that over half these years had periods of zero flow.

Method Used For Flow Recommendations

The flows maintaining the low and high level of aquatic habitat potential for the July 1 - April 30 period were determined by direct observation of flow conditions as they relate to the estimated requirements of various aquatic species inventoried and consideration was also given to flow recommendations for reach #2, upstream of reach #3.

Future flow recommendations for the high water period (May 1 - June 30) will be based on the dominant discharge/channel morphology concept (see page 5). The information needed to derive these flows is presently unavailable.

Flow Recommendations

The flows providing a low and high level of aquatic habitat potential, based on the considerations previously discussed, are 60 and 100 cfs, respectively.

The bankfull flow for reach #3, estimated by the 1 $\frac{1}{2}$ -year frequency peak flow, is about 2,600 cfs. This flow should be established for 24 hours during June. For the remainder of the high water period (May 1 - June 30), the 70% exceedance flows, presently undetermined, are recommended. This information will be available when flow records for the USGS gage at Mosby are summarized.

The instream flows that will maintain a low and high level of aquatic habitat potential are partially identified in Table 38. Instream flows recommended for reach #3 of the Musselshell River correspond to a high level of aquatic habitat potential. The recommended flows are similar to or exceed the mean monthly flows from August through January. Any additional water depletions during this period are undesirable in regard to fish and wildlife benefits.

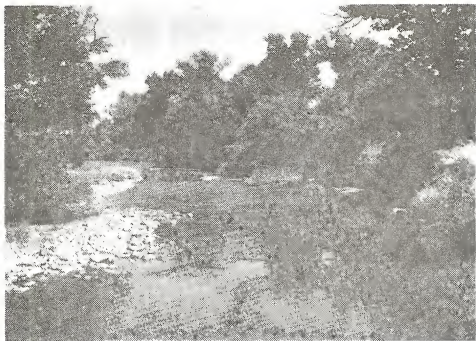
Table 38. Instream flows representing low and high level of aquatic habitat potential compared to mean monthly flows for reach #3 of the Musselshell River.

Time Period	Low ^{1/}		High ^{2/}		Mean	
	CFS	AF	CFS	AF	CFS	AF
January	60	3,689	100	6,149	68	4,187
February	60	3,451	100	5,752	189	10,871
March	60	3,689	100	6,149	386	23,734
April	60	3,570	100	5,950	297	17,673
May	3/		3/		500	30,744
June	3/		3/		954	56,767
July	60	3,689	100	6,149	306	18,815
August	60	3,689	100	6,149	98	6,038
September	60	3,570	100	5,950	85	5,028
October	60	3,689	100	6,149	64	3,911
November	60	3,570	100	5,950	72	4,254
December	60	3,689	100	6,149	71	4,347
Total						186,369

1/ Low level of aquatic habitat potential.

2/ High level of aquatic habitat potential.

3/ Flows presently unidentified.



Musselshell River near Martinsdale



Musselshell River near Harlowton



Musselshell River near Roundup



Musselshell River near Mosby

ENVIRONMENTAL CONCERNS ON THE MUSSELSHELL



Severe bank erosion upstream from Mosby on the mainstem



One of the many diversion dams on the mainstem (upstream from Lavina)

1. NAME OF STREAM OR RIVER

Redwater River

2. STREAM REACHES

From town of Circle (T19N, R48E, S8) to East Redwater Creek (T25N, R50E, S26) and from East Redwater Creek to the mouth (T27N, R50E, S26)

3. DESCRIPTION OF RIVER

The Redwater River is located in extreme eastern Montana in McCone, Dawson and Richland counties. It empties into the Missouri River near the town of Poplar. The river's source is about 80 miles southwest of the mouth (Figure 56). The drainage area is approximately 2,000 square miles. The East Redwater Creek is the only important tributary. It empties into the Redwater River about 15 miles north of the Missouri River.

Much of the river consists of long pools up to several feet deep with short infrequent riffles. Some gravel is present in riffles, but sand and silty bottoms are abundant. The lower river is often 50 to 100 feet wide, but narrower in the upstream areas. Velocities in pools are near zero at low flows.

The river drains rolling prairie. Much of the watershed is rangeland, but there is considerable dry land forming. A true riverbottom vegetation is mostly lacking. Low shrubs and grasses are the common riverbank vegetation. Aquatic vegetation is sparse.

A U.S. Geological Survey gage is located on the upper river near the town of Circle. More recently a gage has been installed below the mouth of East Redwater Creek. Approximately 40 years of record are available for the upstream gage, but only 2 years are available for the downstream gage. The mean annual discharge at the upstream gage is approximately 10,000 acre-feet. Discharge farther downstream is poorly defined, but is known to be much greater.

Streamflow in the Redwater River is extremely variable. Flows vary from zero in some years to several thousand cfs. The annual discharge peak has occurred most frequently in March from snowmelt, but in one

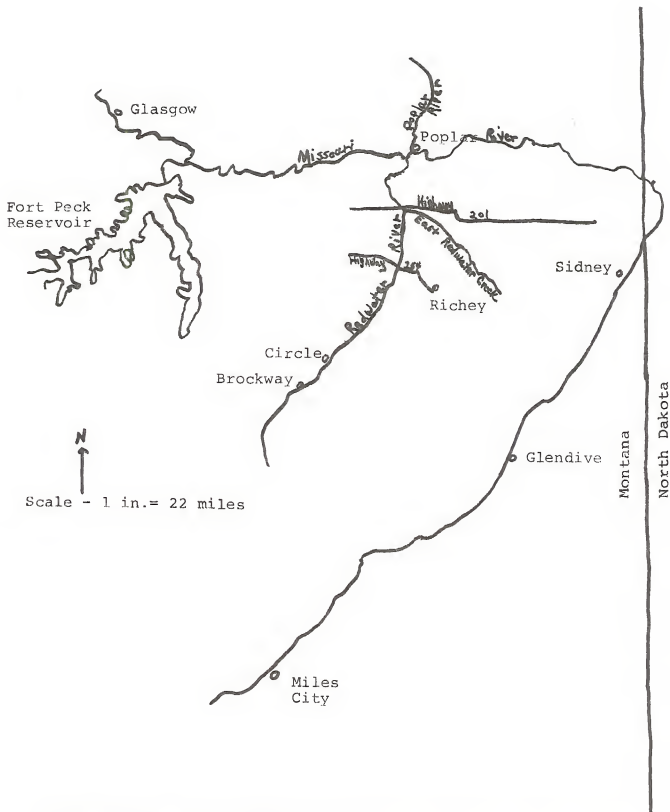


Figure 56. Map of a portion of eastern Montana showing the Redwater River.

or more years the runoff peak has occurred in February, April, May, June, July and September. Relatively large discharges from rain are common in May, June and July. Extended periods of flows less than 1 cfs are common in winter, late summer and fall.

Fish species composition of the Redwater River is given by Needham (1976) who found 22 species. An additional three species were found near the mouth in 1978. Most of these species are small cyprinids. Others are Iowa darter, green sunfish, brook stickleback, stonecat, black bullhead, shorthead redhorse, white sucker, river carsucker, goldeye, carp, northern pike and walleye. Sauger, burbot and channel catfish were found in 1978, but only near the mouth.

Of the game fish only northern pike were found near the town of Circle (Table 1). Numbers appeared to be very low there. Somewhat larger numbers including young-of-the-year (Table 39) are present from the highway 254 bridge downstream, indicating northern pike reproduction in this reach of the river.

Walleye were found from the East Redwater Creek to the mouth (Table 39), however, numbers appeared fairly low. Only a single young-of-the-year was found. This was near the mouth; none were found at upstream points. There appears to be very little walleye reproduction in the Redwater River.

Channel catfish, burbot and sauger were found only in a 1 mile section at the mouth. These species are probably migrants from the Missouri River.

No estimates of fishing pressure or harvest have been made, but fishing pressure is probably low due to the low human population near the river and lack of recognition of the fishery by residents in more populated areas.

Coal and related development may be a problem for the Redwater River in the future. Considerable stippable coal is present in the drainage. Industrial plans for development of McCone County coal have been made public, but no exact timetables have been disclosed.

4. METHODS USED FOR FLOW DETERMINATION

Flows were chosen to maintain only a low level of aquatic habitat potential because the game fish population involved are rather sparse and because natural flows in most of the drainage are poorly known.

The dominant discharge (explained elsewhere) was chosen for the month of March, during which this flow frequently occurs naturally. Calculated dominant discharges at various points in the drainage were supplied by the U.S. Geological Survey. Flows increasing to and decreasing from the dominant discharge were chosen to approximate natural runoff patterns in the Redwater River.

Table 39. Game fish captured by seining and electrofishing in the Redwater River, 1978.

Location ^a and Date	Sauger		Walleye		Northern Pike		Burbot		Channel Catfish	
	Adult	Age 0+	Adult	Age 0+	Adult	Age 0+	Adult	Age 0+	Adult	Age 0+
Near mouth 4-4	9	0	3	0	6	0	8	0	1	0
Near mouth 8-30			1	1	3	2			8	0
Near mouth 10-25	2	0	3	0	2	0	1	0		
201 bridge 7-10			1	0	2	2				
201 bridge 10-26			6	0	9	4				
254 bridge 7-11					1	13				
Near Circle 7-11					2	0				

a See map (Figure 56) for locations.

Flows chosen for the remainder of the year are low base flows to keep some water over riffles and a small exchange of water in pools. They are mostly below average, but still within the range of flows that occur during the various months.

5. FLOW DETERMINATION

Instream flows for a low level of aquatic habitat potential are shown in Tables 40 and 41. The dominant discharges are 990 cfs and 2500 cfs for the upstream and downstream reaches, respectively.

Flows for the remainder of the year are considerably less than average monthly flows (Tables 40 and 41), except for fall and early winter when natural flows are very low.

Table 40. Instream flows representing a low level of aquatic habitat potential compared to mean monthly flows for the Redwater River from the town of Circle to the East Redwater Creek.

Time Period	Instream Flow		Mean Flow	
	CFS	AF	CFS	AF
January	0.2	12.3	0.27	16.6
February	1.0	55.5	20.3	1127
March	5.0	307	81.9	5036
		4245 ^a		
April	3.0	179	23.3	1386
May	2.0	123	3.7	226
June	3.0	179	10.2	607
July	3.0	184	14.3	879
August	2.0	11.9	2.6	157
September	0.2	11.9	0.36	21.4
October	0.2	12.3	0.19	11.7
November	0.2	11.9	0.36	21.4
October	0.2	12.3	0.19	11.7
November	0.2	11.9	0.19	11.3
December	0.2	12.3	0.38	23.4
		5452		9502.4

a Additional water during a 7-day period for the month of March according to the following pattern:

Day	CFS	AF
1	100	198
2	990	1964
3	400	794
4	300	595
5	200	397
6	100	198
7	50	99
		4245

Table 41. Instream flows representing a low level of aquatic habitat potential compared to mean monthly flows for the Redwater River from the East Redwater Creek to the mouth.

Time Period	Instream Flow		Mean Flow ^b	
	CFS	AF	CFS	AF
January	2.0	123	2.0	123
February	2.0	111	77	4276
March	5.0	307 ^a	71	4366
		9024		
April	5.0	297	23	1369
May	5.0	307	9.4	578
June	3.0	179	92	5474
July	2.0	123	84	5165
August	2.0	123	3.4	209
September	2.0	119	1.9	113
October	2.0	123	4.1	252
November	2.0	119	5.0	298
December	2.0	123	3.9	240
Totals		11078		22463

a Additional water during a 7-day period for the month of March according to the following pattern:

Day	CFS	AF
1	100	198
2	2500	4959
3	1000	1983
4	500	992
5	300	595
6	100	198
7	50	99
		9024

b Calculated from only 2 years of gaging data and thought to be low.

1. NAME OF STREAM OR RIVER

Poplar River

2. STREAM REACH

Entire Poplar River system including the West, Middle and East forks from the U.S.-Canadian border to the confluence with the Missouri River at the town of Poplar.

3. DESCRIPTION OF STREAM OR RIVER

The Poplar River is a low-gradient, sinuous prairie stream originating in Saskatchewan. It flows into the Missouri River near the town of Poplar, Montana (see map, Figure 57). The drainage area is 3,329 sq. mi., approximately 37% of which is located in Canada (Poplar River Task Force, 1976). The mean annual discharge for 39 years of record is 98,460 acre feet (USGS, 1976).

The drainage consists of three forks of approximately equal size. All three forks originate in Saskatchewan. The Poplar River upstream of the East Fork is often called the Middle Fork.

The walleye and northern pike are the most abundant game species present. Sauger and smallmouth bass are also present in the downstream portions of the drainage. Various cyprinids are abundant. These include carp, creek chub, northern redbelly dace, flathead chub, lake chub, emerald shiner, brassy minnow, silvery/plains minnow, fathead minnow and longnose dace. Other species in the drainage are river carpsucker, shorthead redhorse, white sucker, brook stickleback, Iowa darter, black bullhead, channel catfish, stonecat, yellow perch, freshwater drum and bigmouth buffalo (Needham 1976).

The Poplar River is physically quite dissimilar from most of the tributaries of the Missouri River to the west. The stream gradient is only a few feet per mile, resulting in a stream made up of long pools (often $\frac{1}{2}$ mile in length) and short riffles. Except during spring runoff there is no measurable velocity in the pools. The stream might be described as a series of long, narrow ponds connected by short riffles.

Bottom types consist mostly of gravel in riffles and varying proportions of gravel, sand and silt in pools. The upper few miles of the East Fork Poplar River in the U.S. differ in that gravel is less common and fine sediments are more abundant.

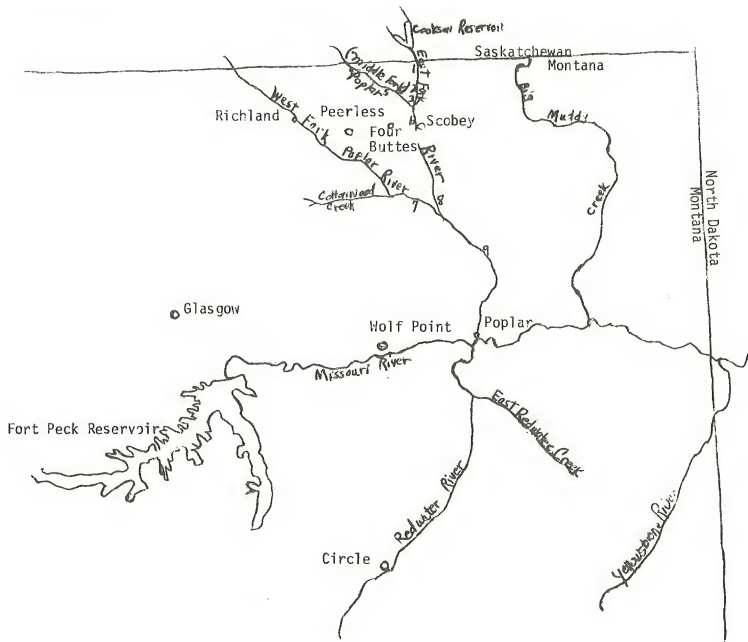


Figure 57. Map of northeastern Montana showing Poplar River drainage.

Streambank vegetation is relatively sparse, consisting mostly of grasses and small shrubs, of which rose and snowberry are the most common. The floodplain vegetation consists largely of grasses, small forbs, silver sage, rose and snowberry. The typical prairie river bottom vegetation of cottonwood and large shrubs is found only along the lower few miles of river near the town of Poplar.

Emergent and submerged aquatic vegetation are not abundant in most of the Poplar River with the exception of the East Fork for a few miles near the Canadian border. In this reach of the East Fork submerged vegetation is often heavy during summer and emergent shore vegetation is also abundant.

Streamflow in the Poplar drainage is highly variable. Monthly mean flows for four points in the drainage are shown in Table 42. Lowest flows occur in winter and highest flows are reached between early March and late April when snow melts. Sharp peaks in the hydrograph from snowmelt are almost an annual occurrence. For example, average daily flows on the Middle Fork at the international boundary from March 16, 1976 to April 4, 1976 were: 0, 56, 910, 1840, 1120, 917, 848, 759, 527, 578, 457, 364, 301, 184, 138, 128, 146, 132, 63 (USGS 1976). Winter flows of less than 1 cfs are common in upstream portions of the drainage.

Physical data for five stream sections of 1.5-2.1 miles in length are shown in Table 43. The Poplar River is not deep. Many pools at low flow have maximum depths of no more than 5 feet. Mean section depths are mostly 1.5-2.0 feet. Riffles often make up only 10% of the stream length.

Although the Poplar River is certainly one of the better warm water stream fisheries in Montana, the fishery exists under marginal physical conditions. Some streams in eastern Montana which are similar physically and hydrologically do not support game fish populations or support limited game fish populations only at the downstream end. In early 1978 much of the Poplar River froze to the bottom. Ice depths in many pools were over 4 feet. Dissolved oxygen was also at stress levels during this period. A partial walleye and northern pike kill occurred due to these conditions in the East Fork and possibly in other portions of the drainage. Any significant decreases in winter dissolved oxygen or pool depth would probably greatly reduce numbers of walleye in large portions of the drainage.

Numbers of walleye and northern pike per mile were determined for seven stream sections in the drainage in 1977 (Stewart 1978). Numbers of walleye per mile were mostly between 100 and 200. Northern pike were most variable ranging from only a few to nearly 200 per mile. Walleye and/or northern pike are present in all of the U.S. portion of the drainage with the exception of the upper West Fork Poplar River. A point on the West Fork straight south of Peerless is the approximate upstream limit of game fish.

Table 42. Approximate mean monthly discharges (in cfs) for points on the Poplar River drainage.^a

Location	J	F	M	A	M	J	J	A	S	O	N	D
Middle Fork at Border	0.1 ^b	0.7 ^b	69.9	93.1	17.7	17.1	6.3	2.0	1.5	2.6	1.9 ^b	0.8 ^b
East Fork at Border	0.8 ^b	1.8 ^b	63.3	78.9	14.4	7.8	5.2	4.4	4.1	4.5	6.8 ^b	4.5 ^b
West Fork near Four Buttes	0.6 ^b	0.9 ^b	133.0 ^b	199.8 ^b	26.4 ^b	23.8 ^b	6.8 ^b	3.9 ^b	2.7 ^b	3.3 ^b	2.5 ^b	1.3 ^b
Poplar River near town of Poplar	5.8	13.9	320.5	989.8	142.9	93.3	52.0	20.7	20.6	22.9	24.9	15.0

a Poplar River Task Force, 1976

b Estimated natural flow

Table 43. Physical data for five stream sections in the Poplar River drainage, 1977.^a

Location	Stream Discharge (cfs)	Length (feet)	Mean Width (feet)	Mean Depth (feet)	% of Section	
					As Riffle	> 3' deep
East Fork	4.9- 5.6	7,560	75.7	2.70	5.3	44.6
East Fork	5.6- 7.3	10,010	43.8	1.81	7.9	23.0
Middle Fork	1.0 ^b	7,525	48.8	1.51	13.2	12.6
West Fork	2.5 ^b	8,950	44.3	1.20	20.0	4.2
Main River	3.5-10.0 ^b	10,990	60.7	1.55	7.2	10.1

a From Stewart 1978

b Approximate

Estimates of angler use of the Poplar River have not been made, but use is thought to be low. Fish tag returns have been mostly from anglers residing in Roosevelt and Daniels counties. The Poplar River is not well known outside of northeastern Montana. This part of the state is sparsely populated which explains the relatively low use.

Initial fisheries work on the Poplar River has been reported by Needham 1976. He gives distribution and relative abundance of the various fish species. Stewart (1978) has reported additional aquatic work including stream channel measurements, stream temperature, dissolved oxygen, bottom fauna, game fish spawning data, larval fish sampling, game fish reproductive success, and game fish population estimates.

The East Fork Poplar River was impounded in 1976 in Saskatchewan, 2 miles north of the Canadian border to form a cooling reservoir for a coal-fired electrical generating complex being constructed adjacent to the reservoir. Since that time, flows in the East Fork Poplar River immediately downstream from the dam have consisted only of seepage from the base of the dam. Occasional spills over the dam will occur during periods of high inflow after the dam fills.

A plan to divide the flow of the Poplar River between Canada and the U.S. has been developed (Poplar River Task Force 1976). This plan has not been implemented. The Poplar River Water Quality Board has been formed under the International Joint Commission. A report from this group is expected in 1979. Effect of the proposed Poplar River flow diversion on water quality and biology will be reported by the Water Quality Board.

4. METHODS USED FOR FLOW DETERMINATION

Poplar River fish populations exist for weeks and even months at a time (Table 42) with flows of 1 or 2 cfs in the upper reaches of the drainage and 5-10 cfs in lower portions. The snowmelt period (typically late March or early April) produces much larger flows of several hundred to several thousand cfs depending on the year and location in the drainage. Late spring and early summer rains typically produce intermediate flows.

The methods used to determine minimum instream flows to support walleye and northern pike basically consisted of the following:

- A. Determination that walleye and northern pike were in fact existing at the very low flows that occur seasonally in the drainage.
- B. Identification and quantification of flows needed to allow spawning and egg incubation of walleye and northern pike in the spring.

- C. Quantification of larger flows (dominant discharge, see page for discussion) necessary to maintain the existing gravel riffles utilized for walleye spawning and pool depth used by both species for most of the year.

Fish studies were made using electrofishing and seining (see Stewart 1978 for a detailed methods description). Population estimates were made using the Petersen mark-recapture method.

Dominant discharges were calculated by the U.S. Geological Survey (Helena office) under contract to the Montana Department of Fish and Game. Duration of flows leading up to and down from the dominant discharge peak were chosen to approximate natural runoff patterns. Considerable use was also made of published USGS flow data, unpublished USGS flow data for 1977 and 1978 and flow summaries from the Poplar River Task Force, 1976.

Determination of flows to support northern pike and walleye spawning and egg incubation (months of April and May) was made by comparing April and May flows for the years 1977 and 1978 with the population size of walleye and northern pike young-of-the-year formed in those years. Flows in those years were varied and the dam on the East Fork in Canada provided an exceptionally low flow in April and May 1977.

Flows chosen are designed to maintain walleye and northern pike populations at levels similar to those found in 1977 and 1978. This is similar to the "high level of maintenance" used in upstream portions of the Missouri River drainage. Flows for a low level of maintenance are not known.

5. FLOW DETERMINATION

Minimum flows for the months of June through March are somewhat lower, for the most part, than average monthly flows (Tables 44-50). These flows were chosen because fish populations appear to be maintained with these somewhat below average flows.

The months of December, January and February are an exception in some cases. This is a period of stress for walleye and northern pike due to low dissolved oxygen in portions of the drainage and thick ice conditions which crowd fish into the deepest portions of the stream. Ice depths in much of the drainage exceeded 4 feet early in 1978. Very little of the stream is deeper than 4 feet (see Table 43). It was also the investigator's feeling that mean flows calculated from USGS data are probably somewhat low, due to problems in measuring streamflow during periods of ice cover. Figures 58 and 59 show typical stream cross-sections at flows characteristic of the low flow period of the year.

Estimates for numbers per mile of young-of-the-year walleye and northern pike in 1977 and 1978 are shown in Table 51. Both walleye and northern pike year classes failed in the East Fork in 1977.

Table 44. Instream and mean flows for the upper reach of the East Fork Poplar River from the International Boundary to Highway 13 bridge 6.5 miles south of boundary (T37N, R48E, S5 to T36N, R48E, S3).

Time Period	Instream Flow		Mean Flow	
	CFS	AF	CFS	AF
January	2.0	123	0.8	49
February	2.0	111	1.8	100
March	5.0	307	63.3	3892
		5790 ^a		
April	15.0	893	78.9	4695
May	10.0	615	14.4	885
June	5.0	298	7.8	464
July	3.0	184	5.2	320
August	3.0	184	4.4	270
September	3.0	178	4.1	244
October	3.0	184	4.5	276
November	2.0	119	6.8	404
December	2.0	<u>123</u>	4.5	<u>277</u>
Totals		9109		11876

a Additional water during a 14-day period to start no earlier than March 15 nor later than April 5 according to the following pattern:

Day	Cfs	AF
1 & 2	50	198
3 & 4	200	793
5	1070	2122
6 & 7	300	1190
8 & 9	200	793
10 & 11	100	397
12, 13 & 14	50	297
		<u>5790</u>

Table 45. Instream and mean flows for the lower reach of the East Fork Poplar River from the Highway 13 bridge 6.5 miles south of the International boundary to the mouth (T36N, R48E, S3 to T36N, R48E, S33).

Time Period	Instream Flow		Mean Flow	
	CFS	AF	CFS	AF
January	3.0	184	0.6	37
February	3.0	167	1.9	106
March	5.0	307	102.5	6302
		10375 ^a		
April	15.0	893	142.9	8503
May	10.0	615	18.9	1162
June	5.0	298	12.7	756
July	4.0	246	10.1	621
August	4.0	246	7.4	455
September	4.0	238	6.9	410
October	4.0	246	7.3	447
November	3.0	178	4.3	256
December	3.0	184	2.0	123
Totals		14177		19180

- a Additional water during a 14-day period to start no earlier than March 15 nor later than April 5 according to the following pattern:

Day	CFS	AF
1 & 2	50	198
3 & 4	400	1587
5	1780	3531
6 & 7	700	2777
8 & 9	400	1587
10 & 11	100	397
12, 13 & 14	50	297
		10375

Table 46. Instream and mean flows for the Poplar River (Middle Fork-upper reach) from the International Boundary to an intermittent tributary (T37N, R45E, S2 to T37N, R46E, S27).

Time Period	Instream Flow		Mean Flow	
	CFS	AF	CFS	AF
January	1.0	61	0.1	6
February	1.0	56	0.7	39
March	5.0	307	69.9	4298
		5076 ^a		
April	30.0	1785	93.1	5540
May	20.0	1230	17.7	1088
June	4.0	238	17.1	1018
July	3.0	184	6.3	387
August	1.0	61	2.0	123
September	1.0	60	1.5	89
October	2.0	119	2.6	160
November	2.0	123	1.9	113
December	1.0	61	0.8	49
Totals		9361		12910

- a Additional water during a 14-day period to start no earlier than March 15 nor later than April 5 according to the following pattern:

Day	CFS	AF
1 & 2	50	198
3 & 4	200	793
5	710	1408
6 & 7	300	1190
8 & 9	200	793
10 & 11	100	397
12, 13 & 14	50	297
		5076

Table 47. Instream and mean flows for the Poplar River (Middle Fork - lower reach) from intermittent tributary to mouth of East Fork (T37N, R46E, S27 to T36N, R48E, S33).

Time Period	Instream Flow		Mean Flow	
	CFS	AF	CFS	AF
January	1.0	61	0.1	6
February	1.0	56	0.8	44
March	5.0	307	111	6825
		6346 ^a		
April	40.0	2380	158	9402
May	30.0	1844	32	1968
June	4.0	238	28	1666
July	3.0	184	10.8	664
August	2.0	123	3.2	197
September	2.0	119	2.5	149
October	2.0	123	4.0	246
November	2.0	119	2.3	141
December	1.0	61	0.7	61
Totals		11961		21369

a Additional water during a 14-day period to start no earlier than March 15 nor later than April 5 according to the following pattern:

Day	CFS	AF
1 & 2	50	198
3 & 4	300	1190
5	950	1884
6 & 7	400	1587
8 & 9	200	793
10 & 11	100	397
12, 13 & 14	50	297
		6346

Table 48. Instream and mean flows for the Poplar River from the mouth of the East Fork to the mouth of the West Fork (T36N, R48E, S33 to T32N, R49E, S22).

Time Period	Instream Flow		Mean Flow	
	CFS	AF	CFS	AF
January	3.0	184	0.7	43
February	3.0	166	2.7	150
March	10.0	615	214	13127
		16264 ^a		
April	70.0	4165	301	17907
May	50.0	3074	51	3130
June	10.0	595	41	2422
July	5.0	307	21	1285
August	5.0	307	11	652
September	5.0	298	9.4	559
October	5.0	307	11.3	695
November	5.0	298	6.6	397
December	3.0	184	2.7	184
Totals		26764		40551

a Additional water during a 14-day period to start no earlier than March 15 nor later than April 5 according to the following pattern:

Day	CFS	AF
1 & 2	100	397
3 & 4	500	1983
5	2500	4959
6 & 7	1200	4760
8 & 9	600	2380
10 & 11	300	1190
12, 13 & 14	100	595
		16264

Table 49. Instream and mean flows for the Poplar River from the mouth of the West Fork to the Missouri River (T32N, R49E, S22 to T27N, R51E, S18).

Time Period	Instream Flow		Mean Flow	
	CFS	AF	CFS	AF
January	5	307	5.8	357
February	5	278	14	778
March	20	1230	321	19738
		24396 ^a		
April	170	10116	990	58909
May	140	8608	143	8793
June	40	2380	93	5534
July	20	1230	52	3197
August	10	615	21	1291
September	10	595	21	1249
October	10	615	23	1414
November	10	595	25	1488
December	5	307	15	922
Totals		51272		103670

a Additional water during a 14-day period to start no earlier than March 15 nor later than April 5 according to the following pattern:

Day	CFS	AF
1 & 2	300	1190
3 & 4	1000	3967
5	3500	6942
6 & 7	1500	5950
8 & 9	800	3174
10 & 11	500	1983
12, 13 & 14	300	1190
		24396

Table 50. Instream and mean flows for the West Fork Poplar River from the county bridge 6 miles south of Peerless to the mouth (T34N, R45E, S15 to T32N, R49E, S22).

Time Period	Instream Flow		Mean Flow	
	CFS	AF	CFS	AF
January	1.0	61	0.6	37
February	1.0	56	0.9	50
March	10.0	615	133	8178
		11256 ^a		
April	50	2975	200	11900
May	30	1845	26	1599
June	3.0	179	24	1428
July	3.0	184	7	430
August	2.0	123	4	246
September	2.0	119	3	178
October	2.0	123	3	178
November	2.0	119	2.5	149
December	1.0	61	1.3	80
Totals		17716		24453

a Additional water during a 14-day period to start no earlier than March 15 nor later than April 5 according to the following pattern:

Day	CFS	AF
1 & 2	75	298
3 & 4	500	1983
5	1300	2579
6 & 7	800	3174
8 & 9	500	1983
10 & 11	200	793
12, 13 & 14	75	446
		11256

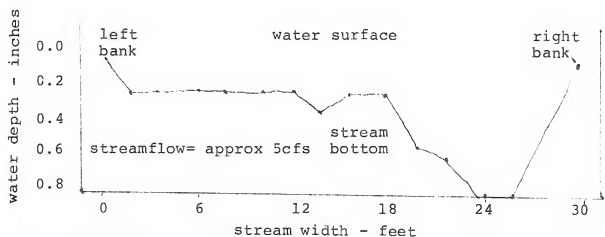


Figure 58. Typical Poplar River riffle X-section at low flow.

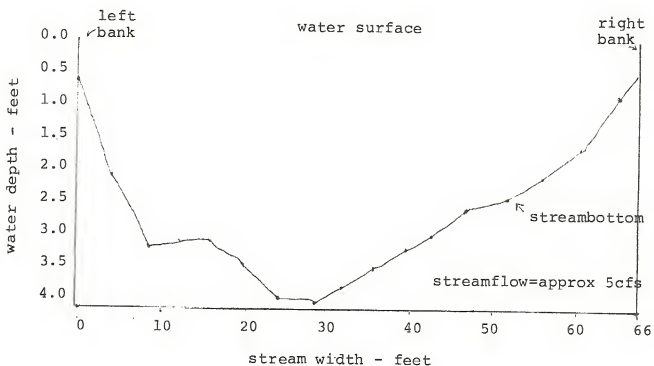


Figure 59. Typical Poplar River pool X-section at low flow.

Table 51. Number estimates of young-of-the-year walleye and northern pike per mile of stream in stream sections in 1977 and 1978.

Section Number	Walleye		Northern Pike	
	1977	1978	1977	1978
<u>East Fork Poplar River</u>				
1 ^a	11	0	0	446
2	4	64	0	0
3	3	136	1	130
<u>Upper (Middle Fork) Poplar River</u>				
4	-	58	-	241
5	186	208	4	97
<u>Main Poplar River</u>				
6	37	66	3	84
8	77	11	28	117
9	-	120	-	80
<u>West Fork Poplar River</u>				
7	61	183	0	53

a See map (Figure 57) for section locations

For the remainder of the drainage numbers per mile of walleye young-of-the-year appeared to be sufficient in both years to maintain the existing adult populations, although numbers produced were somewhat higher in 1978.

Good populations of young-of-the-year northern pike were produced throughout the drainage in 1978, but the numbers produced in 1977 were too low to maintain existing adult populations.

For these reasons instream flows for the spawning and egg incubation months of April and May are similar to those that occurred during spawning and egg incubation in April and May 1978. Mean, maximum and minimum flows at four points in the drainage for April and May 1977 and 1978 are shown in Table 52. The elevated flows that were measured in the East Fork in May 1977 did not begin until the middle of the month, which was too late to be of benefit to whatever small numbers of walleye and northern pike eggs that may have been present. Walleye and pike eggs mostly hatched before mid-May in 1977.

Flows for the spring snowmelt period were chosen to approximate the dominant discharge (see discussion page 5). The 2 week period for duration of flows rising to and falling from the dominant discharge was chosen to approximate the natural runoff pattern.

Table 52. Mean, maximum and minimum flows for the months of April and May, 1978 (1977 in parenthesis) at four points on the Poplar River drainage.^a

<u>April</u>			<u>May</u>		
<u>Mean</u>	<u>Max</u>	<u>Min</u>	<u>Mean</u>	<u>Max</u>	<u>Min</u>
<u>East Fork Poplar River Near International Boundary</u>					
2.9(2.4)	3.6(2.9)	2.3(2.0)	3.0(17.1)	3.7(58)	2.6(1.8)
<u>East Fork Poplar River Near Town of Scobey^b</u>					
38(6.6)	125(1.1)	10(3.2)	8(17.9)	10(164)	3(2.4)
<u>Poplar River (Middle Fork) Near International Boundary</u>					
75.4(11.1)	709(15)	20(9.1)	25.6(12.4)	47(82)	12(4.3)
<u>Poplar River Near Town of Poplar</u>					
681(122)	4630(210)	139(38)	150(31)	205(42)	100(27)

a Unpublished data from the U.S. Geological Survey

b 1978 data is approximate

PRELIMINARY
SUMMARY OF RESOURCE CONFLICTS AND CONCERNS

RIVERS & STREAMS	Dewatering/ Fishery Conflicts Exist			Water Temperature Problems Exist			Water Quality Problems Exist			Riparian Habitat Enhancement Plan Needed	
	<u>High Med Low</u>			<u>High Med Low</u>			<u>High Med Low</u>			<u>Portion Only Entire Length</u>	
Madison River				x							
West Gallatin River	x										
East Gallatin River							x			x	
Gallatin River		x			x						
Beaverhead River	x					x			x		x
Big Hole River	x				x						
Ruby River		x							x		x
Red Rock River		x									
Jefferson River		x				x					
Boulder River	x					x		x			x
Ben Hart Creek											x
O'Dell Creek											
Poindexter Slough								x			
Thompson Creek								x			x
Missouri River Headwaters to Canyon Ferry Res.						x			x		
Sixteenmile Creek											x
Prickly Pear Creek	x								x		x
Missouri River Holtz Dam to the mouth of Smith R.											
Little Prickly Pear Cr.			x								
Big Spring Creek								x			x
Belt Creek								x			x
Smith River		x			x						
Marias River		x			x			x			
Musselshell River	x				x			x			x
Redwater River					x ^{1/}			x			
Poplar River					x ^{1/}				x ^{1/}		

^{1/} East Fork only.

RIVERS & STREAMS	Flows Influenced By Dams	Flow Mgt. Plan Needed	Flow Mgt. Plan Exists	Flow Data Insufficient
Madison River	x	x	x ^{2/}	
West Gallatin River				
East Gallatin River				x
Gallatin River				
Beaverhead River	x	x		
Big Hole River				x
Ruby River	x	x		
Red Rock River	x	x		x
Jefferson River				x
Boulder River				x
Ben Hart Creek				x
O'Dell Creek				x
Poindexter Slough				x
Thompson Creek				x
Missouri River Headwaters to Canyon Ferry Res.	x			
Sixteenmile Creek				x
Prickly Pear Creek				
Missouri River Holtz Dam to the mouth of Smith R.	x	x	x ^{2/}	
Little Prickly Pear Cr.				x
Big Spring Creek	x			
Belt Creek				
Smith River	x			x
Marias River	x	x		
Musselshell River	x		x ^{2/}	
Redwater River				
Poplar River	x	x		x

^{2/} Informal agreement only

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